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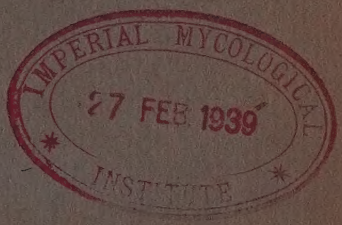

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TABLE DES MATIÈRES

Pages

MATHÉMATIQUES

S. Finikoff. Déformation d'une surface avec l'extension des lignes d'une famille 3
A. G. Pinsker. Sur l'extension des espaces semi-ordonnés 6

PHYSIQUE STELLAIRE

M. S. Eigenson. The Surface Brightness of the Night Sky and the Infinity of the Astronomical Universe 10

PHYSIQUE

M. N. Podaschewsky und **A. M. Polonsky.** Über Luminiszenz von Alkalihalogenidkristallen 14
J. S. Shur. Influence of Heat Treatment in a Magnetic Field upon the Distribution of the Spontaneous Regions of a Ferromagnetic Monocrystal 18
D. Blokhintzev and **B. Davydov.** Some Contributions to the Theory of Solid Rectifiers 21
K. S. Wulfson et **M. I. Lombert.** Dispersion de la lumière dans les cristaux du quartz 25
A. I. Alichanian and **S. J. Nikitin.** β-Ray Spectrum of RaC and Energy Levels of Excitation of RaC' Nucleus 28
D. Iwanenko. Simple Applications of the Proca Potential 31
A. Sokolov. On the Nature of the Heavy Electron 34

CHIMIE PHYSIQUE

D. I. Mirlis and **A. I. Gluchova.** The Kinetics of Wetting and the Linear-Selective Corrosion of Metals in Polyphase Systems 35
W. Stern, B. Kravetz et **A. Sokolik.** L'action de CO_2 sur l'auto-inflammation du mélange hexane—air 40

BIOCHIMIE

M. G. Kritzmann. Isolation of the Enzyme Transferring the Amino-Group of Glutamic Acid 42
A. V. Vladimirov and **G. V. Liaskovskaja.** Age and Daily Variations of Citric Acid Content in Leaves of *Nicotiana rustica* 44

PÉTROGRAPHIE

G. D. Afanassiev. Showings of Rare Metal Mineralization in the South-Eastern Part of Mountainous Altai 47

GÉNÉTIQUE

A. I. Zuitin and **M. T. Pavlovetz.** Age Differences in Spontaneous Mutation in Males of *Drosophila melanogaster* of Different Origin 50
A. I. Zuitin. The Influence of the Change of the Thermal Regime upon the Frequency of Occurrence of Lethal Mutations in *Drosophila melanogaster* 53
A. I. Zuitin. The Combined Effect of Change of the Thermal Regime and the Subsequent Temperature Contrast upon the Frequency of Lethal Mutations in *Drosophila melanogaster* 56
G. D. Karpechenko. New Tetraploid Barleys—the Hulled and the Naked 59
V. I. Patrushev. Blood Value of Cross-Breeds between the Wild *Ovis Polii Karelini* Sew. and the Domestic Sheep 63
A. P. Sokolovskaja and **O. S. Strelkova.** Polyploidy in the High Mountain Regions of Pamir and Altai 68

PHYSIOLOGIE VÉGÉTALE

L. M. Dorokhov. Dynamics of Carbohydrate Accumulation in Plant Leaves as Influenced by Different Content of CO_2 in Air 72
L. M. Dorokhov. Effect of CO_2 upon Transpiration and Stomatic Apparatus in Plants 77

ANATOMIE DES PLANTES

V. G. Alexandrov and **O. G. Alexandrova.** On Structure of Furrow in Wheat Kernel 81

PHYTOPATHOLOGIE

L. M. Dorokhov. Alteration of Physiological Processes in Tomato under the Influence of *Cladosporium fulvum* Cke 85

ZOOTECHNIQUE

V. I. Patrushev. Blood Value of Yaroslavl Cattle in Correlation with Body Weight and Yield of Milk 89

PALÉONTOLOGIE

K. K. Flerov. Remains of *Ungulata* from Bet-pak-dala 94

Rédacteur en chef A. Fersman. Rédacteur S. Bernstein.

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MATHÉMATIQUES

DÉFORMATION D'UNE SURFACE AVEC L'EXTENSION DES LIGNES D'UNE FAMILLE

Par S. FINIKOFF

(Présenté par N. N. Lusin, de l'Académie, le 1.VIII.1938)

1. Par définition, une surface S s'applique sur S' avec l'extension des lignes d'une famille (s) si l'on peut établir une correspondance biunivoque entre les points de S et S' telle que les lignes (σ), orthogonales à (s), restent orthogonales et conservent leur longueur. Nous appellerons le réseau (s, σ) la base de l'extension.

Il est bien connu que dans chaque correspondance ponctuelle biunivoque entre deux surfaces S et S' il existe un réseau de lignes égales à leurs homologues. Il est facile à voir que dans la correspondance de l'applicabilité avec extension à la base (s, σ) toutes les deux familles du réseau coïncident avec les lignes σ. Inversement, chaque correspondance dont les deux familles du réseau de lignes égales coïncident, est une correspondance de l'applicabilité avec extension. En effet, il suit de l'égalité des éléments linéaires:

$$E\,du^2 + 2F\,du\,dv + G\,dv^2 = E_1 du^2 + 2F_1\,du\,dv + G_1 dv^2,$$

à condition que les deux familles des lignes égales coïncident avec les lignes $v = \text{const}$,

$$E = E_1,\ F = F_1.$$

Si $F = 0$, on a $F_1 = 0$, c'est-à-dire les lignes u, v composent la base de l'extension (s, σ) de S, S'.

2. Inversement, quelles que soient deux surfaces S et S' et une famille de lignes (s) sur S, on peut déterminer l'applicabilité de S sur S' avec l'extension des lignes (s).

Rapportons S aux lignes (s) et leurs trajectoires orthogonales (σ) et soit

$$ds^2 = A\,d\alpha^2 + B\,d\beta^2 \qquad (1)$$

son élément linéaire. Si $ds_1^2 = E_1 du^2 + 2F_1\,du\,dv + G_1 dv^2$ est l'élément linéaire de S' rapporté aux paramètres arbitraires u, v, le problème se réduit à la détermination des fonctions $\alpha = \alpha(u, v)$, $\beta = \beta(u, v)$ et B_1 telles que

$$E_1 du^2 + 2F_1\,du\,dv + G_1 dv^2 = A\,d\alpha^2 + B_1 d\beta^2, \qquad (2)$$

d'où il résulte le système:

$$A\left(\frac{\partial\alpha}{\partial u}\right)^2+B_1\left(\frac{\partial\beta}{\partial u}\right)^2=E_1,\quad A\left(\frac{\partial\alpha}{\partial v}\right)^2+B_1\left(\frac{\partial\beta}{\partial v}\right)^2=G_1,$$
$$A\frac{\partial\alpha}{\partial u}\frac{\partial\alpha}{\partial v}+B_1\frac{\partial\beta}{\partial u}\frac{\partial\beta}{\partial v}=F_1 \tag{3}$$

qui détermine α, β, B_1 avec deux fonctions arbitraires d'un seul argument. Notons que l'équation (2) permet, évidemment, de remplacer β et B_1 par

$$\overline{\beta}=f(\beta),\ \overline{B}_1=B_1f'^{-2}(\beta). \tag{4}$$

Donc, il existe une infinité de différentes façons d'applicabilité de S sur S' à la même base (α, β).

3. Si (s) est une famille de lignes géodésiquement parallèles, σ sont géodésiques de même que les lignes homologues σ' de S'.

Inversement, si l'on donne deux surfaces S et S' et une famille de lignes géodésiquement parallèles (s) ou (s') sur chaque surface, on établit une correspondance biunivoque arbitraire entre les géodésiques σ et σ' orthogonales à (s) ou à (s') et on détermine sur chaque couple de géodésiques homologues σ, σ' une correspondance ponctuelle conservant leur longueur et telle qu'une ligne s soit transformée en ligne homologue s'. Toutes les autres lignes de (s) correspondent à leurs homologues (s') et S est applicable sur S' avec l'extension des lignes (s).

4. On obtient un problème plus restreint si l'on examine la correspondance d'applicabilité avec l'extension de lignes (s) établie entre les points de deux morceaux des surfaces S, S' limités respectivement par les lignes L, L' qui correspondent avec conservation de longueur.

Quelle que soit la correspondance d'applicabilité de S, S' avec l'extension des lignes (s), on peut, en général, déterminer sur S resp. S' deux morceaux homologues $\sum$ resp. $\sum'$ tels qu' il y ait une correspondance avec conservation de longueur entre leurs contours L, L'. Rapportons les deux surfaces à la base de l'extension (s, σ) et soit

$$ds^2=Ad\alpha^2+Bd\beta^2,\ ds_1^2=Ad\alpha^2+B_1d\beta^2 \tag{5}$$

leurs éléments linéaires. En posant $ds=ds_1$ et en excluant la solution $\beta=$const on obtient:

$$B=B_1. \tag{6}$$

Si ni B ni B_1 ne contiennent α, les lignes (s) et (s') sont géodésiques, le problème est impossible. Si l'équation (6) admet des solutions $\alpha=\varphi(\beta)$, elles déterminent sur S, S' des lignes L, L' qui correspondent avec conservation de longueur. Si, par exemple,

$$\alpha=\varphi_1(\beta),\ \alpha=\varphi_2(\beta) \tag{7}$$

sont deux solutions de (6), les morceaux $\sum$, $\sum'$ peuvent être limités par deux lignes σ, par exemple, $\beta=\beta_1$ et $\beta=\beta_2$, et par deux arcs de (7) coupés par les lignes choisies σ.

5. Nous allons examiner maintenant la déformation d'un morceau donné $\sum$ d'une surface S limité par un contour L avec l'extension des lignes données (s) et conservation de longueur des arcs homologues de L.

Quelle que soit une surface S', le système (3) détermine un réseau de lignes $\alpha=$const, $\beta=$const qui forment la base de l'extension (s', σ') dans l'applicabilité de S sur S'.

Supposons que L est une ligne unicursale définie sur S en coordonnées curvilignes α, β par les équations:

$$\alpha = \varphi(t), \quad \beta = \psi(t) \tag{8}$$

où t est la variable indépendante sur L. En introduisant les expressions (8) dans les formules (5) on obtient la condition de la conservation de longueur sur L sous la forme de l'équation (6).

Or, nous avons vu que le système (3) admet le changement des variables (4). Soit B_1 la solution de (3) qui correspond aux solutions α, β du même système; B_1 est une fonction de u, v ou bien de α, β. Sur la ligne (8) B_1 est une fonction définie de t. Si B_1 est différente de B, on introduit une nouvelle solution de (3) $\bar{\beta} = f(\beta)$, déterminée par l'équation

$$f'^2(\beta) = \frac{B_1}{B}$$

qui est donnée sur la ligne (8), mais qui détermine $\bar{\beta} = f(\beta)$ sur toute la surface S. La fonction $\overline{B_1}$ qui correspond à la solution $\bar{\beta}$ sera égale à B sur la ligne (8), c'est-à-dire les fonctions α, β déterminent l'applicabilité avec extension du morceau $\sum$ de S sur le morceau homologue $\sum'$ d'une surface arbitraire S' à la base d'extension (s, σ).

6. On peut croire qu'une surface fermée à courbure partout positive admet une déformation avec extension en restant fermée, même si l'on impose la condition supplémentaire, à savoir que, outre les lignes σ, certaines lignes L conservent leur longueur. Je crois cependant qu'il existe pour chaque surface fermée S certaine limite de la déformation, c'est-à-dire qu'il existe parmi les surfaces fermées S' qui s'appliquent sur S aves l'extension des lignes (s) une surface $\overline{S'}$ de plus grand volume. La recherche de cette limite est un problème intéressant, mais difficile.

Université de Moscou.

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MATHÉMATIQUES

SUR L'EXTENSION DES ESPACES SEMI-ORDONNÉS

Par A. G. PINSKER

(Présenté par S. N. Bernstein, de l'Académie, le 16. VIII. 1938)

Indiquons un procédé régulier permettant de construire pour chaque espace semi-ordonné linéaire du type K_5 [1] (espaces de L. Kantorovich) un espace du même type mais plus étendu que nous allons nommer extension de l'espace donné.

Les espaces étendus possèdent des propriétés qui n'ont pas lieu dans les K_5-espaces arbitraires (une Note spéciale sera consacrée à l'étude détaillée de ces propriétés), en particulier, l'extension de l'espace étendu lui est isomorphe. L'opération de l'extension des espaces permet d'introduire quelque généralisations des notions de la convergence (o) et de la convergence (*), à savoir:«la convergence étendue (o)» et «la convergence étendue (*)»; dans plusieurs espaces concrets ces convergences ont un sens simple et naturel. Ainsi, par exemple, l'extension de l'espace L (l'espace des fonctions intégrables) est l'espace S (l'espace des fonctions mesurables), la convergence étendue (o) dans L sera la convergence presque partout, la convergence étendue (*) sera la convergence en mesure.

1. Soit Y un espace du type K_5. Nous appellerons complexe chaque ensemble $A=\{a\}$ d'éléments positifs de Y (y compris zéro) satisfaisant aux deux conditions suivantes:

1) Si $a\in A$ et $a'<a$ $(a'\geqslant 0)$, alors $a'\in A$.

2) Si E est un sous-ensemble borné de A, alors

$$\sup E\in A.$$

Nous désignerons les complexes par les lettres majuscules A, B, etc., et les éléments de l'espace Y par les lettres minuscules a, b, etc.

Posons $A\leqslant B$, si $A\subset B$.

Lemme 1. *L'ensemble* $Y=\{A, B, \ldots\}$ *de tous les complexes possibles de* Y *est un espace semi-ordonné.*

En effet, les axiomes:

A) $A\leqslant A$;

B) si $A<B$ et $B<C$, alors $A<C$;

C) quels que soient les éléments A et B, il existe des éléments C et D tels que $C<A$, $B<D$;

D) chaque ensemble borné supérieurement admet une borne supérieure exacte;

ont lieu dans $\tilde{Y}$, et l'axiome D) est rempli dans la forme la plus générale, à savoir: chaque ensemble de complexes possède un supremum.

Soit $E=\{A\}$ un ensemble de complexes, $E\subset\tilde{Y}$, alors

$$\sup E=\overline{\sum A},$$

où $\overline{\sum A}$ est l'ensemble des éléments de Y appartenant aux complexes A, completé par les supremums de tous les ensembles bornés possibles composés de ces éléments (pour vérifier cette assertion on peut faire usage de l'identité suivante: $x=\sup\limits_{\xi<\vartheta}\{\inf(x,y_\xi)\}$ si $x<\sup\limits_{\xi<\vartheta}\{y_\xi\}$). Définissons dans $\tilde{Y}$ les opérations: l'addition $A+B$, la multiplication par un nombre non-négatif λA $(\lambda\geqslant 0)$ et la soustraction $A-B$ $(A\geqslant B)$. Posons $A+B=\{a+b\}$, où a et b sont tous les couples possibles d'éléments de A et B $(a\in A, b\in B)$; $\lambda A=\{\lambda a\}$ $(a\in A,\ \lambda\geqslant 0)$ et $A-B=\overline{\{a-\sup\limits_{b<a}\{b\}\}}=$ $=\{\overline{a-b^*}\}$ $(A\geqslant B,\ a\in A,\ b\in B,\ \sup\limits_{b<a}\{b\}=b^*)$ (la barre signifie, que l'ensemble $\{a-b^*\}$ est completé par les supremums de tous ses sous-ensembles bornés). Il est facile à montrer, que $A+B, \lambda A\,(\lambda\geqslant 0)$ et $A-B$ $(A\geqslant B)$ sont des complexes.

Lemme 2. *Les relations suivantes sont vraies pour les complexes*:

a) $A+B=B+A$;
b) $(A+B)+C=A+(B+C)$;
c) $\lambda(A+B)=\lambda A+\lambda B\quad(\lambda\geqslant 0)$;
d) $(\lambda_1+\lambda_2)A=\lambda_1 A+\lambda_2 A\quad(\lambda_1,\lambda_2\geqslant 0)$;
e) $\lambda_1(\lambda_2 A)=\lambda_1\lambda_2 A\quad(\lambda_1,\lambda_2\geqslant 0)$;
f) $1\cdot A=A$;
g) $(A-B)+B=A\quad(A\geqslant B)$.

Montrons, par exemple, g). Soit $c\in A-B$ et $c=a-b^*$; on a $c+b=$ $=a-b^*+b=\sup(a,b)+\inf(a,b)-b^*\leqslant\sup(a,b)$, car $\inf(a,b)\leqslant b^*$; ensuite $a, b\in A$, par conséquent, $\sup(a,b)\in A$ et $c+b\in A$. Soit $c=\sup\{a-b^*\}$, alors $c+b=\sup\{a-b^*\}+b=\sup\{a-b^*+b\}\leqslant\sup\{\sup(a,b\}$, il en résulte $c+b\in A$. De cette façon nous avons demontré l'inégalité $(A-B)+B\leqslant A$. Montrons que $(A-B)+B\geqslant A$. En effet, soit $a\in A$, alors $a=(a-b^*)+b^*$ et $a\in(A-B)+B$, d'où il suit que g) est vraie.

2. L'ensemble de tous les complexes $\tilde{Y}$ n'a pas toutes les propriétés d'un ensemble linéaire, ainsi, par exemple, de $X'+A=X''+A$ il ne suit pas en général que $X'=X''$; pour écarter cet obstacle, introduisons la notion de complexe fini, à savoir: un complexe A sera nommé fini, si quel que soit l'élément $a_0\in Y$, $a_0>0$ il ne peut exister qu'un nombre fini d'éléments de la forme $\{na_0\}$ $(n=1,2,\ldots)$ appartenant au complexe A. Dans ce cas nous écrirons $A<+\infty$. L'ensemble des complexes finis A appartenant à $\tilde{Y}$ sera désigné par $\tilde{Y}_+$.

Lemme 3.

a) *Si* $A, B<+\infty$, *alors* $A+B<+\infty$.
b) *Si* $A<+\infty$, *alors* $\lambda A<+\infty\quad(\lambda\geqslant 0)$.
c) *Si* $A<+\infty$ *et* $A>B$, *alors* $B<+\infty$ *et* $A-B<+\infty$.
d) *Si* $A_0<+\infty$ *et* A_0 *est une borne supérieure de l'ensemble* $\{A\}$, *alors* $\sup\{A\}<+\infty$.
e) *Si* $A<+\infty$ *et* $B>0$, *alors* $A+B>A$.
f) *Si* $A, X', X''<+\infty$ *et* $X'+A=X''+A$, *alors* $X'=X''$.
g) *Si* $A<+\infty$ *et* $A\geqslant B+C$, *alors* $A-(B+C)=(A-B)-C$.

Montrons a) et f).

a) Supposons le contraire, alors il existe des éléments $c_0 > 0$, $a_n \in A$ et $b_n \in B$ tels, que $nc_0 \in A+B$ et $a_n+b_n=nc_0$ $(n=1, 2, \ldots)$. Comme $\overline{\lim_{n\to\infty}}\left(\frac{1}{n}a_n+\frac{1}{n}b_n\right)=c_0>0$ et $\overline{\lim_{n\to\infty}}\left(\frac{1}{n}a_n+\frac{1}{n}b_n\right)\leqslant\overline{\lim_{n\to\infty}}\left(\frac{1}{n}a_n\right)+\overline{\lim_{n\to\infty}}\left(\frac{1}{n}b_n\right)$, alors $\overline{\lim_{n\to\infty}}\left(\frac{1}{n}a_n\right)>0$ ou bien $\overline{\lim_{n\to\infty}}\left(\frac{1}{n}b_n\right)>0$. Soit, par exemple, $\overline{\lim_{n\to\infty}}\left(\frac{1}{n}a_n\right)=a_0>0$, dans ce cas $\sup\left(\frac{1}{n}a_n, \frac{1}{n+1}a_{n+1}, \ldots\right)\geqslant a_0$ et $\sup\left(a_n, \frac{n}{n+1}a_{n+1}, \ldots\right)\geqslant na_0$ $(n=1, 2, \ldots)$, mais $\sup\left(a_n, \frac{n}{n+1}a_{n+1}, \ldots\right)\in A$ et, par conséquent, $na_0 \in A$, ce qui est impossible.

f) Tout d'abord on peut démontrer, que

$$\sup(X', X'')+A=X'+A=X''+A.$$

Si $X' \neq X''$, alors $\sup(X', X'')$ est, par exemple, plus grand que X', alors d'après le lemme 2, g)

$$[\sup(X', X'')-X']+X'=\sup(X', X'')$$

et

$$[\sup(X', X'')-X']+X'+A=X'+A,$$

ce qui est impossible [d'après e)].

Lemme 4. *L'ensemble des complexes finis $\overline{Y}_+$ est isomorphe à l'ensemble des éléments positifs d'un certain espace semi-ordonné linéaire du type K_5.*

Considérons l'ensemble $\overline{Y}=\{(A, B)\}$ de tous les couples possibles des éléments de $\overline{Y}_+$.

Posons $(A, B)>0$, si $A>B$; $(A, B)+(C, D)=(A+C, B+D)$; $\lambda(A, B)=(\lambda A, \lambda B)$, si $\lambda \geqslant 0$ et $\lambda(A, B)=(-\lambda B, -\lambda A)$, si $\lambda<0$.

Il en résulte: $(A, B)-(C, D)=(A+D, B+C)$; $(A, B)>(C, D)$, si $A+D>B+C$; $(A, B)=0$, si $A=B$.

L'ensemble $\overline{Y}=\{(A, B)\}$ est un ensemble linéaire. En effet, les sept axiomes d'un ensemble linéaire sont vérifiés pour $\overline{Y}$, a savoir:

1. $(A, B)+(C, D)=(C, D)+(A, B)$.
2. $[(A, B)+(C, D)]+(E, F)=(A, B)+[(C, D)+(E, F)]$.
3. $(C, D)+(A, B)=(C', D')+(A, B)$ implique $(C, D)=(C', D')$.
4. $\lambda[(A, B)+(C, D)]=\lambda(A, B)+\lambda(C, D)$.
5. $(\lambda_1+\lambda_2)(A, B)=\lambda_1(A, B)+\lambda_2(A, B)$.
6. $\lambda_1[\lambda_2(A, B)]=\lambda_1\lambda_2(A, B)$.
7. $1\cdot(A, B)=(A, B)$.

Montrons, par exemple, 3. Si $(C, D)+(A, B)=(C', D')+(A, B)$, alors $(C+A, D+B)=(C'+A, D'+B)$ et $C+A+B+D'=D+B+A+C'$ ou $(C+D')+(A+B)=(D+C')+(A+B)$; d'après le lemme 3, f), nous concluons que $C+D'=D+C'$, c'est-à-dire

$$(C, D)=(C', D').$$

Les axiomes I—V d'un espace semi-ordonné linéaire sont aussi remplis dans l'ensemble $\overline{Y}$, à savoir:

I. Si $(A, B)>0$, alors $(A, B)=0$ est impossible.

II. Si $(A, B)>0$ et $(C, D)>0$, alors $(A, B)+(C, D)>0$.

III. Pour chaque (A, B) on trouvera un (C, D) tel, que $(C, D)>0$ et $(C, D)-(A, B)>0$.

IV. Si $\lambda > 0$ et $(A, B) > 0$, alors $\lambda(A, B) > 0$.

V. Chaque ensemble borné supérieurement E admet une borne supérieure exacte, $\sup E$.

Les axiomes I — IV sont faciles à vérifier. Soit $E = \{(X_\xi, Y_\xi)\}_{\xi<\vartheta}$ l'ensemble des éléments de $\overline{Y}$ et (A, B) — la borne supérieure E, alors

$$\sup_{\xi<\vartheta} E = (A, B + \inf_{\xi<\vartheta}\{(A+Y_\xi)-(B+X_\xi)\}). \qquad (*)$$

Ou peut montrer que l'ensemble $\overline{Y}_+$ est isomorphe à l'ensemble des éléments positifs de $\overline{Y}$ et, comme en vertu de la définition de la borne supérieure $(A+Y_\xi) \geqslant (B+X_\xi)$, alors $\inf_{\xi<\vartheta}\{(A+Y_\xi)-(B+X_\xi)\}$ a un sens. L'égalité (*) résulte des inégalités suivantes:

$$A + Y_\xi \geqslant B + X_\xi + \inf_{\xi<\vartheta}\{(A+Y_\xi)-(B+X_\xi)\},$$

en d'autres termes

$$\sup_{\xi<\vartheta} E \geqslant (X_\xi, Y_\xi).$$

D'autre part, soit (C, D) une borne supérieure arbitraire de E; à l'aide du lemme 3, g) on peut démontrer que

$$(C, D) \geqslant (C, D + \inf_{\xi<\vartheta}\{(C+Y_\xi)-(D+X_\xi)\}) = (A, B + \inf_{\xi<\vartheta}\{(A+Y_\xi)-(B+X_\xi)\}),$$

c'est-à-dire, on voit que $(C, D) \geqslant \sup_{\xi<\vartheta} E$. De cette facon l'axiome V est aussi vérifié dans $\overline{Y}$ et on a le

Théorème 1. *$\overline{Y}$ est un espace semi-ordonné linéaire du type K_5.*

Nous appellerons l'espace $\overline{Y}$ «extension» de l'espace Y. Le terme «extension» est verifié par le théorème suivant:

Théorème 2. *Tout espace est compris dans son extension.* Nous appellerons un complexe borné, si l'ensemble de ses éléments est borné dans Y. L'ensemble $\{(A, B)\}$ des éléments de $\overline{Y}$, où A et B sont des complexes bornés, est isomorphe à l'espace Y.

Théorème 3. *L'extension de l'espace étendu lui est isomorphe.*

3. Soit Y un espace du type K_5 et $\overline{Y}$ — son extension. On peut considérer chaque suite $y_n \in Y$ comme une suite d'éléments de l'espace $\overline{Y}$ (en vertu du théorème 2); nous dirons que la suite $\{y_n\}$ converge au sens étendu (o) dans Y, si elle converge (o) dans $\overline{Y}$. Il est évident, que la convergence (o) est un cas particulier de la convergence étendue (o). D'une maniére analogue on introduit la notion de convergence étendue (*).

4. Indiquons l'extension de quelques espaces concrets.

Théorème 4.

a) *les extensions des espaces: $\tilde{M}$, L^p et S sont isomorphes à l'espace S.*

b) *les extensions des espaces: m, l^p et s sont isomorphes à l'espace s.*

En concluant, nous ferons observer que l'espace étendu peut être défini comme l'espace remplissant la condition suivante: si $y_n \in Y$ et $\inf(|y_i|, |y_j|) = 0$ $(i \neq j)$, alors

$$\sup_n \{y_n\} < +\infty.$$

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ASTROPHYSICS

THE SURFACE BRIGHTNESS OF THE NIGHT SKY AND THE INFINITY OF THE ASTRONOMICAL UNIVERSE

By M. S. EIGENSON

(Communicated by S. I. Wawilow, Member of the Academy, 24. VIII.1938)

The conciliation of the idea of the existence of a finite and low surface brightness of the night sky with the conception of the infinity of the astronomical Universe presents a problem whose solution has been sought by science for more than two centuries past *. The difficulty of the solution was, as is well known (1), one of the principal reasons which induced Einstein in 1916 to renounce the conception of an infinite Universe. It can indeed easily be seen that such a renunciation of the conception of the infinity of the astronomical Universe will in every essential respect (be it in the sense of space finity, or of limitation of the time of cosmic evolution, etc.) offer at least a qualitative explanation of the observed fact of the finite value of the surface brightness of the night sky. Yet, the giving up of the conception of an astronomical infinite Universe is philosophically untenable. The acceptability of such a renunciation is at present strongly disputed on purely observational ground (2). In the light of the aforesaid, it would appear expedient to recall in a few words some of the attempts to solve the problem we are concerned with, as based on the conception of an infinite Universe. Broadly speaking, these attempts may be classed under the following two heads: 1) the hypothesis of Cheseaux (3) and Olbers (4) based upon the idea of cosmic absorption and 2) the hypothesis of Charlier (5) grounded on a specification of the structure of successive «Universes» (Lambert's cosmic systems) (6). The recent work by V. G. Fessenkov (7) occupies a rather special place, being an interesting synthesis of 1) and 2). From a modern standpoint the acceptability of 1) depends in the first place upon: a) the possibility of proving the existence of a sufficiently strong metagalactic absorption and b) on the possibility of providing a satisfactory solution for the energy problem of the latter (i. e. in particular on the possibility to solve the question of what subsequently happens to absorbed optical radiation). At the same time the acceptability of 2) depends obviously upon the possibility of agreeing with some restrictions of geometry of successive «Universes» which were imposed by Charlier** in the case in hand for the

* The first works on this subject were performed by Halley as early as in 1720, as well as by Cheseaux in 1744.

** It may be shown (see our article under a similar title now in print in the Russian Astronomical Journ.) that the modern data on the Galaxy and Metagalaxy render Charlier's geometrical limitation somewhat too close.

very purpose of solving expressedly and particularly the problem of the agreement of a finite surface brightness of the night sky with an astronomical Universe infinite in space. It is necessary to say that the discoveries of cosmic absorption in the Galactic system ([8]) and similar extragalactic spirals ([9]) make, when considered on purely principle grounds, quite unavoidable the synthesis of points of view 1) and 2) of the type proposed by V. G. Fessenkov. So much the more important is then the fact most convincingly brought forward by V. G. Fessenkov, that the acceptability of 2) is now found to be scarcely probable not only from a geometrical but also from a purely physical point of view.

Besides the just stated, there are two more drawbacks common to standpoints 1) and 2): α) both are purely qualitative attempts permitting to understand the cause of the finiteness of the observed surface brightness of the night sky, but both fail to give a theoretical pre-calculation of its observed concrete numerical value; β) both these viewpoints are, as it were, dictated to nature but not deduced therefrom, i. e. we might say that they are constructed by the authors ad hoc, for the explanation of observed facts and do not follow from these facts.

The point of view advanced below is, we believe, free from these shortcomings. In adopting it, we proceeded in our reasoning from the fundamental law of extragalactic kinematics, viz. the law of the red displacement of Hubble-de Sitter:

$$V = Er, \tag{1}$$

where V is Doppler or quasi-Doppler ([10]) velocity determined from the relative displacement $\frac{\Delta\lambda}{\lambda}$ of wave-lengths λ of spectrum lines of extragalactic nebula, r—the distance of the latter, while E—a constant $= +1.8 \cdot 10^{-17}$ sec^{-1}. Law (1) is, as is well known, checked up to utmost distances, R', for which measurable spectra of extragalactic bodies ($R' \sim 2.5 \cdot 10^{26}$ cm) are obtainable. The expounded theory is based on the commonly accepted and very probable surmise as to the possibility of extrapolating (1) up to $r \to R_0$, where

$$R_0 = \frac{c}{E} \tag{2}$$

and c is the velocity of light. It is easily shown that owing to the red displacement the energy of the photon emitted by the nebula located at distance r decreases in case I (if the red displacement is not produced by an actual receding of extragalactic nebulae) $\left(1 - \frac{E}{c} r\right)$ times or in case II (if the red displacement is caused by such receding) $\frac{1 - \frac{E}{c} r}{1 + \frac{E}{c} r}$ times.

On account of this the following two bolometric effects of red displacement should take place: a) phenomena with $r \geq R_0$ will be bolometrically imperceptible, b) in case I the mean absolute brightness of a mean standard nebula found within the range of optically possible observation $r < R_0$ will be by 25% less than the absolute brightness of a similar standard but near-ranging nebula; thus, this mean nebula will in absolute units be weaker than a near nebula and this by $1^m.5$ (3); in case II in place of the last mentioned figure there will be found a somewhat greater value equalling $1^m.75$ (4). [It is familiar that up to distance R'', being at present the farthest photographically accessible range ($R'' = 5 \cdot 10^8$ light years $= 5 \cdot 10^{26}$ cm), the metagalactic function of density $D(r)$ (equal to the number of Galaxy in 1 volume of Me-

tagalaxy)=const. On account of this, its constancy is also highly probable with $r \gtrsim R''$]. Let us denote by $\rho(r)$ the linear radius of the screening region of the nebula*. Then radius R_{00} of the sphere of complete screening will be determined from the relation:

$$4\pi = \int_0^{R_{00}} \frac{\pi \rho^2(r)}{r^2} 4\pi r^2 D(r)\, dr. \qquad (5)$$

Assuming, as this is the case when $r \lesssim R''$, that $\rho(r)$=const and knowing $D(r)$ and $\rho(r)$ for $r < R''$, it will be easy to show that

$$\frac{R_{00}}{R_0} \sim 10^3. \qquad (6)$$

If, instead of (6), we had

$$R_0 = R_{00}, \qquad (7)$$

then, the extragalactic component of surface brightness of the night sky would evidently be equal to the mean surface brightness of the mean extragalactic nebula which lies within the bolometrically observable range $r < R_0$. However, since in reality we have (6) and not (7), the extragalactic component of the surface brightness of the night sky should be by $2.5 \log \frac{R_{00}}{R_0}$, i. e. $7^m.5$ (8), weaker than this mean surface brightness of an average nebula.

Elsewhere the author has shown that the mean photographic surface brightness of nearer elliptic nebulae against the background of the nocturnal sky constitutes, according to Harvard data, $22^m.2/1''\square$. Since the mean photographic surface brightness of the latter $=22^m.1/1''\square$ ([11]), the absolute illumination proceeding from an average elliptical nebula =2 objects $22^m.2/1''\square$, i. e. it is equal to $21^m.45/1''\square$. Yet, our calculations of mean surface brightnesses of nebulae were carried out with the help of data on their apparent integral brightnesses, based upon the results of the study of small-scale plates, as well as information on their angular diameters obtained from the study of large-scale plates. Due to this heterogeneity of the material we start with, there arises the necessity of reduction** $=-2^m.25/1''\square$, owing to which the mean absolute photographic surface brightness of an average nearer elliptical nebula may be determined as equal to $19^m.2/1''\square$ (9).

In addition to the bolometrical effects a) and b) there exists, on account of the rather black body's character of the curve for the distribution of energy in a nebula spectrum, also c) the photographic effect of red displacement. It is just easy to show that by virtue of b) the spectrum type of the mean standard nebula will, within the range $r \cdot R_0$, be dM instead of dG_2, which is the case for a spectrum type of a close standard nebula. This lowering of the effective temperature of an average standard nebula from $\sim$6000° K down to 3400° K brings about its reddening and a decline in its photographic brightness by $2^m.22$ (10) as compared with a nearer standard nebula. Summing up all the above-stated, we find on the basis of (3).

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* The term screening implies such an action of a physically and optically more dense central region of a closer nebula upon a light flux of an yet farther nebula passing through the nearer nebula towards the observer, in result of which the light emission becomes practically imperceptible.

** The details both of this reduction and of the whole work are to be found in the above-cited full account of our investigation in the Russian Astronomical Journal.

(4), (8), (9) and (10) that upon the assumptions made the extragalactic component of the surface brightness of the night sky may be declared to be of the following order:

$$30^m.4/1'' \square \text{ (I) or } 30^m.6/1'' \square \text{ (II).}$$

Let us now compare this theoretical value with observational evidence. Accordind to V. G. Fessenkov (12), upon the deduction of the probable values of the components corresponding to the Earth, the planets and the Galaxy, there will fall to the share of the extragalactic component no more than 0.01 of a star of 5^m in $1° \square$, or in the above-adopted units no more than $27^m.8/1'' \square$ (12). By comparing (11) with (12) we shall see that, notwithstanding the very provisory character of these figures, theoretical calculation proves not to contradict observation.

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PHYSIK

ÜBER LUMINISZENZ VON ALKALIHALOGENIDKRISTALLEN

Von M. N. PODASCHEWSKY und A. M. POLONSKY

(Vorgelegt von S. I. Wawilow, Mitglied der Akademie, d. 15.VIII.1938)

§ 1. Die ultraviolette Luminiszenz des röntgenisierten Steinsalzes ist von einer Reihe von Verfassern untersucht worden, nämlich von Kudrjawzewa (1), Glässer und Beasley (2), Schein und Katz (3, 4), Djatschenko (5) u. a. Doch werden in den veröffentlichten Arbeiten bedeutende Meinungsverschiedenheiten betreffs der erhaltenen Resultate beobachtet, was durch relativ schwache Intensität der ultravioletten Ausstrahlungen und die daraus folgenden experimentellen Schwierigkeiten erklärt werden kann.

Eine genaue Erforschung der Spektren der Luminiszenz und der Gesetze ihrer Abklingung ist von bedeutendem Interesse für das Herstellen eines Schemas der Energiezustände der Elektronen, für das Feststellen ihres Übergangsmechanismus und die Befestigung im Kristallgitter, sowie für eine weitere Aufklärung des Wesens der photochemischen und photoelektrischen Eigenschaften der reellen Kristalle.

Den angeführten Erwägungen gemäss haben wir eine systematische Erforschung der Luminiszenz von Alkalihalogenidkristallen unternommen. Um die allergrösste Genauigkeit zu sichern, wurden optische Apparate mit doppelter Spektralzerlegung und einem höchstempfindlichen Lichtzählrohr benutzt.

Fig. 1 stellt das Schema des optischen Teiles der Anordnung dar. Die Abbildung des Kristalls Kr, der in Kardanische Gelenke befestigt ist (zur Untersuchung der Ausdehnungsdeformation), wird mittels eines achromatischen Quarzsystems KQ auf die Auftrittsspalte eines doppelten Quarzmonochromators M projiziert; L_1 ist die Quelle, die die photochemische Verfärbung erzeugt (eine Quecksilberquarzbogenlampe, eine kondensierte Funkenentladung oder ein Röntgenrohr); L_2—eine Wolframpunktlichtlampe, mit Gleichstrom gespeist, zur Untersuchung der Kristallfluoreszenz, wie auch der inneren Spannungen nach der optischen Methode; N_p und N_a sind Nicolsche Prismen; F_1 und F_2—Schottsche Lichtfilter RG2 und RG7; O_1 und O_2—achromatische Objektive; Q—ein Schuzquartzplättchen; S—der Verschluss; D_1 und D_2—Diaphragmen. Die Intensität der spektralzerlegten ultravioletten Ausstrahlung wurde mittels eines Platinowasserstoff-Zylinder-Lichtzählrohrs nach Schein und Stoll (6) gemessen. Das Lichtzählrohr ZR wurde von der Austrittsspalte des Monochromators innerhalb der Metallschutzkammer K eingestellt; mittels eines Dreikaskadenimpulsverstärkers auf Widerstand schaltete der Zähler einen mechanischen Registrierungsmechanismus ein.

Die ganze Anordnung wurde sorgfältig untersucht und graduiert. Es wurden nachgeprüft: die Dispersionskurven des Monochromators, das ehlen der Ermüdung des Lichtzählrohrs, die Proportionalität der Entladungszahl zur Intensität der einfallenden Strahlung für verschiedene Wellenlängen,

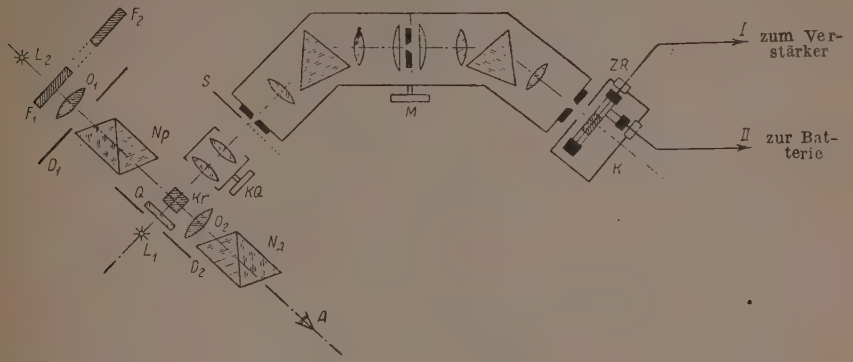

Fig. 1.

die Abhängigkeit der Zahl der Dunkelentladungen von der Anodenspannung, dieselbe Abhängigkeit bei ständiger Beleuchtung verschiedener Intensität und das Auflösungsvermögen des mechanischen Zählers. Die Zahl der Dunkelentladungen überschritt nicht 0.5—1.5 pro Minute und wurde vor Beginn und zum Ende jeder Beobachtungsserie gemessen. Eine Korrektion auf Spektralempfindlichkeit der Photokathode wurde nach Roich's ([8]) Angaben.

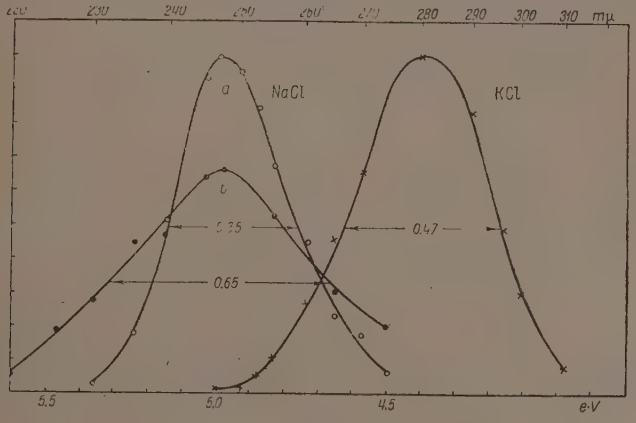

Fig. 2.

aus der Graduierung des Lichtzählrohrs nach der Emission eines absolut schwarzen Körpers vorgenommen. Die Spektralmessungen wurden unmittelbar nach der photochemischen Einwirkung, welche von 5 Sekunden bis zu einigen Minuten dauerte, ausgeführt. Meistenteils wurde bei Erforschung der Luminiszenz, die infolge der Lichtwirkung entsteht, die Entfärbung durch entsprechende ergänzende photochemische Verfärbung kompensiert. Dies sicherte uns das Erhalten genau reproduzierbarer Ergebnisse. Im Falle einer Untersuchung sehr stark verfärbter Kristalle wurde eine Entfärbung in unseren Versuchsbedingungen nicht beobachtet.

§ 2. Die in der Literatur vorhandenen Angaben über das Luminiszenzspektrum sind widerspruchsvoll. So wurde von einigen Verfassern[1,2] ein Luminiszenzstreifen mit einem Maximum von ungefähr 245 mμ festgestellt, während Schein und Katz [3, 4] über zwei Streifen berichten, deren Lage nicht in die bestehenden Schemen der Elektronen-

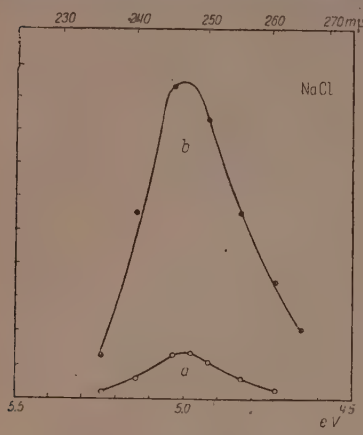

Fig. 3.

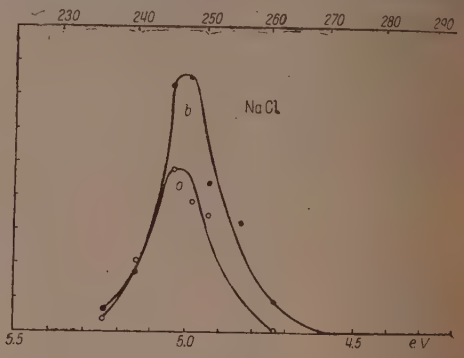

Fig. 4.

niveaus untergebracht werden kann und einer Reihe photoelektrischer und optischer Angaben widerspricht. Demzufolge beabsichtigten wir vorerst die Spektralverteilung der Luminiszenz von NaCl und KCl-Kristallen genau festzustellen und die Einwirkung verschiedener Faktoren auf diese Verteilung zu erforschen. Es wurden Luminiszenzspektra von Steinsalzkristallen untersucht, wie ungetemperter, getemperter, so auch plastisch deformierter getemperter Kristalle, welche einer photochemischen Verfärbung durch ultraviolette und Röntgenstrahlen unterworfen wurden. Im ganzen wurden 55 Kristalle untersucht. Die Ergebnisse lauten wie folgt:

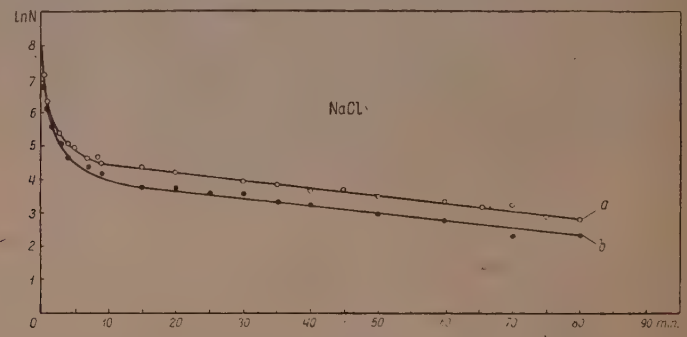

Fig. 5.

1. Steinsalzkristalle geben in allen Fällen nur einen Luminiszenzstreifen mit einem Maximum bei 4.98 eV (λ =248 mμ) (Fig. 2—5, wo auf den Abszissenaxen eV und λ, auf den Ordinaten die Intensität in relativen Einheiten abgelegt sind).

2. Analog ist für synthetische KCl-Kristalle das Maximum bei 4.4 eV (λ =220 mμ), die Halbwertsbreite des Streifens bei 0.45 eV (Fig. 2).

3. Die Halbwertsbreite des Luminiszenzstreifens bei ungetemperten Kristallen ist bedeutend grösser, als bei getemperten, und ist entsprechend 0.65 eV und 0.35 eV gleich (Fig. 2, *b* und *a*).

4. Das Maximum des Luminiszenzstreifens getemperter, durch ultraviolette oder durch Röntgenstrahlen verfärbter Steinsalzkristalle ist übereinstimmend, jedoch hat der Luminiszenzstreifen röntgenisierter Kristalle eine grössere Halbwertsbreite und einen merklichen Ausläufer, der sich in den langwelligen Teil des Spektrums erstreckt.

5. Das Phosphoreszenzspektrum, das nach Anregung des Kristalls mit ultravioletten Strahlen erhalten wird, fällt ganz mit dem Luminiszenzstreifen, welcher bei Zusatzbelichtung mit sichtbarem Lichte entsteht, zusammen. Die Zusatzbelichtung vergrössert nur mehrmals die Intensität der Luminiszenz (Fig. 3, *a*—Phosphoreszenzspektrum, *b*—Spektrum bei Zusatzbelichtung).

6. Das Luminiszenzspektrum hängt nicht von der Art der Luminiszenzerregung ab, dieselben Streifen werden auch bei Wärmeeinwirkung auf einen verfärbten Kristall beobachtet.

7. Die von uns beobachteten NaCl und KCl-Luminiszenzspektra stimmen mit dem von Tartakowsky (7) vorgeschlagenen Schema der Elektronenniveaus gut überein.

8. Die Einwirkung der plastischen Deformation auf vorläufig verfärbte Kristalle äussert sich in der Abschwächung der Luminiszenz, während Kristalle, die vor der photochemischen Verfärbung deformiert wurden, eine bedeutende Verstärkung der ultravioletten Ausstrahlung zeigen. Diese Wirkung wird besonders stark bei ultraviolett verfärbten Kristallen ausgesprochen, während röntgenisierte Kristalle weniger empfindlich zur Deformation sind.

Spektraluntersuchung erweist eine bedeutende Erweiterung des Luminiszenzstreifens deformierter Kristalle im langwelligen Gebiet (Fig. 4, *a*—vor der Deformation, *b*—nach der Deformation).

Das Bestehen eines zweiten, von Katz (4) beschriebenen Luminiszenzstreifens bei deformierten Kristallen wurde von uns nicht festgestellt, obwohl in unseren Versuchsbedingungen eine Ausstrahlung beobachtet werden konnte, deren Intensität 200 Mal geringer ist, als die Intensität des Grundstreifens. Der von diesem Verfasser angeführte Unterschied in den Gesetzen der Phosphoreszenzabklingung für deformierte und undeformierte Kristalle wurde von uns auch nicht bestätigt. Die von uns erhaltenen Abklingungskurven für verfärbte ungetemperte, getemperte und plastisch deformierte Kristalle erweisen, dass in allen diesen Fällen die Abklingung nach einem dem exponentialnahestehenden Gesetze vor sich geht, mit einer bedeutenden Abweichung in den ersten 5—10 Minuten (Fig. 5, wo auf den Axen die Zeit in Minuten und die Logarithmen der Impulszahlen in einer Zeiteinheit abgelegt sind).

Die Deformation erzeugt blos eine Gesamtvergrösserung der Impulszahl, wobei der Neigungswinkel der Geraden unverändert bleibt (Fig. 5). Die Abklingungskurven können mehrmals bei wiederholter Belichtung durch erregendes sichtbares Licht genau wiedergegeben werden, jedoch unter der Bedingung, dass die Intensität zwecks Vermeidung einer Entfärbung nicht zu gross sei.

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PHYSICS

INFLUENCE OF HEAT TREATMENT IN A MAGNETIC FIELD UPON THE DISTRIBUTION OF THE SPONTANEOUS REGIONS OF A FERROMAGNETIC MONOCRYSTAL

By J. S. SHUR

(Communicated by S. I. Wawilow, Member of the Academy, 10.VIII.1938)

1. In our previous brief communication (1) we have already shown that the process of annealing in a magnetic field is liable to alter considerably the character of the anisotropy of the coercive force of ferromagnetic monocrystals. This phenomen may be quantitatively interpreted as follows. The natural crystal anisotropy of coercive force is determined by the form of magnetic energy of anisotropy in the given specimen. Annealing in a magnetic field is apparently liable to produce an appreciable distortion of the normal shape of the curve of this energy; the direction coinciding with the direction of the magnetic field during annealing becomes in many cases the axis of the easiest magnetization. If this surmise be true, heat treatment in a magnetic field should have a definite influence upon the pattern of the «powder figure» on the surface of monocrystals [the so-called «Bitter figures» (2)], this being due to the fact that these figures, as shown experimentally within recent years (3), are decidedly related to the way in which the spontaneous regions of different orientation are distributed in a monocrystal.

The present work was undertaken for the very purpose of obtaining preliminary data on the influence of heat treatment in a magnetic field upon the pattern of powder figures.

2. In order to obtain a complete answer to the question in hand it was necessary to make observations upon a whole collection of monocrystals with various crystal orientation.

For our first qualitative investigations we accordingly took as experimental material a coarse-grained polycrystal of silicon iron with 3.5 per cent Si, the linear section of individual grains in it being from 2 to 10 mm while the thickness of the specimen was 0.5 mm. From the optical reflections from the surfaces of separate crystals the inference could be made that there existed in this particular piece crystals with the greatest variety of orientation. By careful polishing the surface of the specimen was brought to such a state that under magnifications commonly used in experiments it was impossible to detect any traces of scratch. A powder obtained by means of the reduction of ferrominium in petroleum vapours at high temperature was taken in capacity of magnetic powder. For obtaining the magnetic suspension this powder was pulverized down to a grain size of the order of one micron and was then suspended in pure alcohol. The magnetization of the test-piece

was effected perpendicular to its surface, with the help of a straight electromagnet.

3. The experiment was carried out in the following way. After polishing, the sample was placed under magnetic shelter and underwent heating up to 800° C in a high vacuum, whereupon it was slowly cooled in the furnace with power off. Owing to the availability of high vacuum ($\sim 10^{-5}$ mm Hg), the surface of the specimen even after annealing remained as lustrous and smooth as it had been immediately after polishing. The sample was then placed on the pole of a straight electromagnet after which its surface was coated with a thin layer of the magnetic suspension. After 1—2 minutes there appeared sharply outlined «Bitter figures» which readily lent themselves to microscopic examination with magnifications of 25—50 diameters. The patterns formed by the powder figures on different crystals were photographed, due notice being taken in the angle between the direction of the bands and a certain conventional line on the sample. Further on, the same observations were made after annealing the test-piece in a magnetic field directed in the plane of the specimen under a certain angle to the conventional line.

In all these observations we discerned on various crystals «Bitter figures» which mostly had the shape of nearly parallel lines running in most different directions. While observing the patterns of these powder figures under the microscope, it was possible to detect their displacement ensuing upon a change of the direction of the field in a straight electromagnet.

4. The results of the influence of heat treatment in a magnetic field upon the distribution of powder figures are represented in the table.

α is the angle between the direction of the powder bands and a certain conventional direction on the surface of the specimen; β is the angle between the same conventional line and the direction of the magnetic field in course of heat treatment.

Crystal No	α (degree)			
	After annealing under magnetic shelter	After annealing in a magnetic field with		
		$\beta=0°$	$\beta=45°$	$\beta=90°$
1	0	0	0	0
2	60	—	45	—
3	90	0	—	90
4	10	0	45	90
5	45	—	—	90
6	50	50	45	90
7	60	—	45	—
Group of small crystals (2 mm in section)	45	0	45	90

Figs. 1 and 2 illustrate the direction of figures on crystal № 5 after annealing in two mutually perpendicular directions. The direction of the magnetic field during heat treatment is indicated by an arrow.

5. Analysis of the table shows that heat treatment in a magnetic field produces, depending upon the orientation of each individual crystal, a different effect upon the powder figures, namely:

a) On some crystals no effect was noticeable.

b) In some cases bands appearing in one direction vanished after annealing in another direction.

c) With the bulk of the crystals, the bands strictly follow the direction of the magnetic field in the specimen during heat treatment.

The results of these experiments are in good agreement with our investigation on the influence of heat treatment in a magnetic field upon the anisotropy of coercive force. Namely, the effect of annealing in a magnetic field is directly dependent upon the orientation of a monocrystal; while it

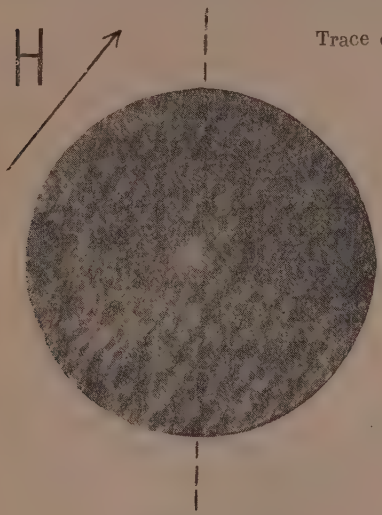

Fig. 1. × 35

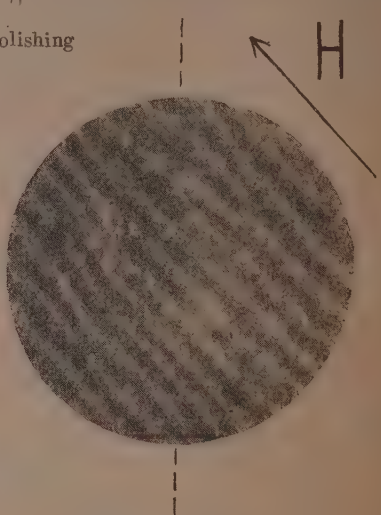

Fig. 2. × 35

should be noted that for certain orientations of the crystal it causes a but inconsiderable decrease of H_c and for others a very strong one.

6. From this investigation of the behaviour of «Bitter bands» after heat treatment in a magnetic field the following two conclusions can be drawn:

a) Heat treatment of a ferromagnetic monocrystal in a magnetic field shows, along with other investigations, that «Bitter bands» stand in a direct dependence upon the character of distribution of spontaneous regions in monocrystals.

b) Heat treatment in a magnetic field in many cases strongly affects the shape of the curve of magnetic energy of anisotropy in a monocrystal.

The experimental part of this work was carried out with the help of A. I. Popov, student of the Sverdlov State University.

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PHYSICS

SOME CONTRIBUTIONS TO THE THEORY OF SOLID RECTIFIERS

By D. BLOKHINTZEV and B. DAVYDOV

(Communicated by A. F. Joffe, Member of the Academy, 19. VII. 1938)

It was previously pointed out by one of us (1) that an electric current, when made to pass through the boundary between two electronic semi-conductors of various type (free electrons and positive «holes»), causes changes in the concentration of free charges in the vicinity of this boundary involving a rectification of current. In the present paper we propose to show that similar changes of concentrations arise also in course of the passage of current through the boundary between two semi-conductors of the same type but possessing different specific resistance.

Let, for instance, the two semi-conductors possess a normal electronic conductivity. Let us denote their specific resistances by ρ' and ρ'' respectively, and let $\rho' \gg \rho''$. In the passing of a direct current at some distance from the contact (plane $x=0$) there should be set up, in each of the semi-conductors respectively, fields

$$E_0' = i\rho' \text{ and } E_0'' = i\rho''$$

(sign' refers everywhere to the first semi-conductor, and sign'' to the second). Close by the contact the field ought to change from E_0' to E_0''. It is usually assumed that the charges producing this change in the field lie at the very boundary between the semi-conductors, so that they may be considered as the surface density of electricity. Yet these are, in reality, volumetric charges and it will be shown below that the thickness of the layer in which they are located may be quite considerable.

These volumetric charges arise partly at the expense of free charges, i. e. in our case at the expense of free electrons. Their sign depends on the direction of the current. Consequently, there will be set up close to the contact a density of free charges which will be either enhanced or lowered depending on this direction. This involves rectification. With given P. D., current will be greater when the free charges proceed from the lower resistance to the higher one(2).

With $i=\text{const}$ we have in each of the semi-conductors:

$$u\left(eEn + kT\frac{dn}{dx}\right) = i. \qquad (1)$$

Besides this, we have Poisson's equation:

$$\varepsilon \frac{dE}{dx} = 4\pi e (N_n - N). \tag{2}$$

Here n denotes the concentration of free electrons, N — the concentration of «excited» electrons, i. e. electrons both fixed and free, lying at energy levels situated above the level of the chemical potential (Fermi's boundary); similarly, N_n denotes the concentration of unfilled levels lying below the chemical potential («stationary positive holes»). For greater ease we consider the number of «free holes» to be so small as to be negligible.

Let, with current off:

$$n = n_0; \quad N = N_n = \gamma n_0, \quad \gamma \geqslant 1. \tag{3}$$

With current on, as many free electrons should, however, disappear at every point, as these are again produced by thermal motion $\left(\text{since } \frac{di}{dx} = 0\right)$. Accordingly, at every point we ought to have as before Fermi's distribution, but, possibly, with changed chemical potential. Let us denote this change of the chemical potential by the letter ζ. Then

$$n = n_0 e^{\frac{\zeta}{kT}}; \quad N = \gamma n, \quad N_n = \gamma n_0 e^{\frac{\zeta}{kT}}. \tag{4}$$

Substituting this in (2) we obtain ultimately:

$$\varepsilon \frac{dE}{dx} = 4\pi e \gamma \frac{n_0^2 - n^2}{n}. \tag{2a}$$

(1) and (2a) give us two equations for two unknown functions n and E. The boundary conditions with $x = 0$ will be:

$$\varepsilon' E' (0) = \varepsilon'' E'' (0), \tag{5}$$

$$\frac{n' (0)}{n_0'} = \frac{n'' (0)}{n_0''}. \tag{6}$$

Condition (6) is obtained from the requirement that the numbers of free electrons falling at the boundary from right and left would be equal. In reality they ought to differ by $\frac{i}{v}$, where v denotes the mean normal component of thermal velocity. However, this difference can be left out of account, if i is not too high. No leaps whatever of field or potential are to be introduced since we consider that only volumetric charges are available.

Equations (1) and (2a) are non linear and to find their exact solution presents great difficulties. We shall propose approximate solutions for low current, disposing all magnitudes according to degrees of i. The first approximation is, of course, given by Ohm's law, and in order to evaluate the rectification it will be necessary to find the second approximation.

Let us assume that

$$n = n_0 + n_1 + n_2 + \ldots; \quad E = E_1 + E_2 + \ldots \tag{7}$$

Here signs 1, 2, . . . refer to terms proportional to i, i^2, . . . In the first approximation accounting only for terms proportional to the first degree of i, we have:

$$u\left(eE_1n_0+kT\frac{dn_1}{dx}\right)=i, \qquad (1')$$

$$\varepsilon\frac{dE_1}{dx}=-8\pi e\gamma n_1. \qquad (2')$$

Hence

$$E_1=E_0+ae^{\varkappa x}, \text{ where } \varkappa=\pm\sqrt{\frac{8\pi\gamma n_0e^2}{\varepsilon kT}}. \qquad (8)$$

Here

$$E_0=i\rho=\frac{i}{eun_0}. \qquad (9)$$

If the thickness of each semi-conductor is $\gg\frac{1}{\varkappa}$, then for the first semi-conductor we must take $\varkappa'>0$, for the second $\varkappa''<0$. $\frac{1}{\varkappa}$ is Debye's length. Boundary conditions (5) and (6) give together with (2'):

$$\frac{a'}{\varkappa'}=-\frac{a''}{\varkappa''}=-\frac{\varepsilon'E_0'-\varepsilon''E_0''}{\varepsilon'\varkappa'+\varepsilon''\varkappa''}. \qquad (10)$$

In the second approximation we have:

$$eE_1n_1+eE_2n_0+kT\frac{dn_2}{dx}=0 \qquad (1'')$$

and

$$\varepsilon\frac{dE_2}{dx}=4\pi e\gamma\frac{n_1^2}{n_0}-8\pi e\gamma n_2. \qquad (2'')$$

This gives

$$\frac{d^2E_2}{dx^2}=\varkappa^2E_2+\frac{ax\varkappa eE_0}{2kT}e^{\varkappa x}, \qquad (11)$$

whence

$$E_2=\left(b+\frac{aeE_0x}{2kT}\right)e^{\varkappa x}. \qquad (12)$$

Boundary conditions give: $\varepsilon'b'=\varepsilon''b''$;

$$\frac{b'}{\varepsilon'}+\frac{b''}{\varepsilon''}=\frac{e}{2kT}\left(\frac{a'E_0'}{\varepsilon'^2}-\frac{a''E_0''}{\varepsilon''^2}\right). \qquad (13)$$

Now we calculate the additional, concentration part of full potential difference:

$$V_c=\int_{-\infty}^{+\infty}(E_1-E_0)\,dx+\int_{-\infty}^{+\infty}E_2\,dx. \qquad (14)$$

The first of these two integrals gives zero. The second gives:

$$V_c=-\frac{e}{kT}\left(\frac{E_0'}{\varkappa'}+\frac{E_0''}{\varkappa''}\right)\frac{\varepsilon'E_0'-\varepsilon''E_0''}{\varepsilon'\varkappa'+\varepsilon''\varkappa''}. \qquad (15)$$

With $E_0'\gg E_0''$ and $\varkappa'\ll\varkappa''$ we have:

$$V_c=-\frac{e}{kT}\frac{\varepsilon'E_0'^2}{\varepsilon''\varkappa'\varkappa''}. \qquad (15a)$$

We have seen above that changes in concentration take place in a layer of thickness of $\sim\frac{1}{\varkappa}$. Ohmic potential difference applied to such a layer in the first semi-conductor with greater resistance will be $V_0=\frac{E_0'}{\varkappa'}$. Consequently,

$$\frac{V_e}{V_0}=-\frac{eV_0}{kT}\frac{\varepsilon'\varkappa'}{\varepsilon''\varkappa''}. \tag{15b}$$

The relative change of concentration in the vicinity of the contact will be of the same order. As to the Debye length with $\gamma n_0=10^{14}$ cm^{-3}, $\frac{1}{\varkappa}\sim 10^{-5}$ cm.

This is a value of the same order as the thickness of the «locking layer» in solid rectifiers.

If the thickness of the «locking layer», i. e. of the first semi-conductor, is d', then the total Ohmic potential difference will be $E_0'd'$ (we neglect the resistance of the second semi-conductor). For differential resistance $R=\frac{dV}{di}$, we have then:

$$-\left[\frac{d\ln R}{dV}\right]_{V=0}=\frac{e}{kT}\frac{2\varepsilon'}{d'^2\varepsilon''\varkappa'\varkappa''}. \tag{16}$$

Here $\varkappa'\ll\varkappa''$. This expression, as well as the whole of the foregoing calculation, is applicable only in the case when $\varkappa' d'\gg 1$. By its value it will consequently always be $\ll\frac{e}{kT}$.

We have just considered two semi-conductors with normal electronic conductivity. All the aforesaid will, of course, hold true also for two semi-conductors with an anomalous, «hole» conductivity. The sign of rectification will in this case be the opposite, i. e. current will be greater when the «holes» will run from the lower resistance to the greater one.

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PHYSIQUE

DISPERSION DE LA LUMIÈRE DANS LES CRISTAUX DU QUARTZ

Par K. S. WULFSON et M. I. LOMBERT

(Présenté par L. I. Mandelstam, de l'Académie, le 20.VII.1938)

La théorie de la dispersion moléculaire de la lumière, développée par H. Leontowitch, S. Mandelstam et P. Mattossi ([1], [2]), conduit à la conclusion que la dépolarisation, de même que l'intensité de la lumière dispersée grâce aux fluctuations calorifiques, dépendent de l'orientation des axes cristallographiques.

P. Mattossi a essayé de vérifier expérimentalement cette théorie avec des cristaux du spath d'Islande et de quartz, mais cette étude ne peut être considérée comme suffisante, car c'est surtout la dépolarisation qui en a été l'objet. La preuve sûre de la nature moléculaire de dispersion de la lumière n'est possible que par l'étude de l'intensité de la lumière dispersée. Comme l'ont montré les recherches antérieures ([3], [4]), l'étude de la variation de l'intensité en fonction de la température peut servir de criterium pour séparer la dispersion moléculaire des effets causés par la non-homogénéité accidentelle. Les expériences décrites dans le présent article ont été effectuées en respectant les conditions mentionnées.

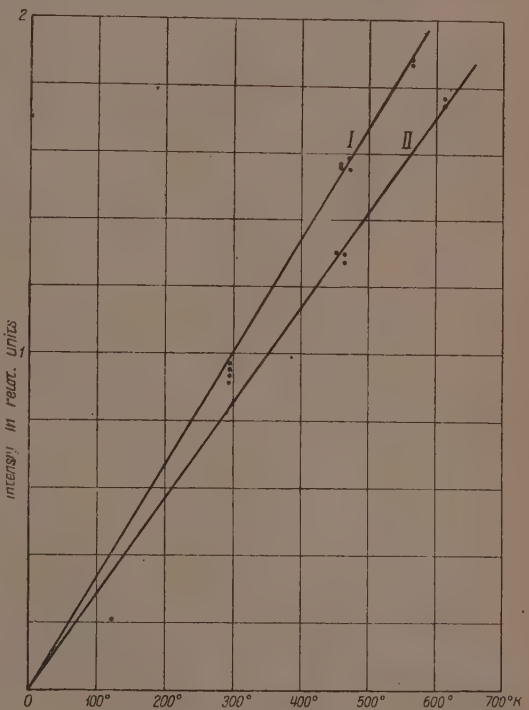

Fig. 1.

Les mesurages ons été faits avec deux meilleurs échantillons, taillés en forme de prismes rectangulaires, dont les faces sont parallèles aux axes optique, électrique et mécanique.

La fig. 1 montre la relation entre l'intensité de la lumière dispersée et la

température, les mesurages étant faits pour deux orientations différentes des axes.

La droite *I* correspond à la position de l'échantillon où l'axe mécanique est orienté suivant l'axe *Z* perpendiculairement au plan de la dispersion, passant par le rayon primitif et la direction de l'observation. La droite *II* correspond à la position de l'axe électrique dirigé perpendiculairement au plan de la dispersion. L'inclinaison différente des droites détermine l'effet qui nous intéresse.

Le tableau 1 donne les rapports des intensités de la lumière pour de différentes positions de l'échantillon, les mesurages étant faits au cours de quelques séries d'observations effectuées sur deux échantillons de quartz.

Tableau 1

	$\frac{I_{méc.}}{I_{électr.}}$	$\frac{I_{opt.}}{I_{méc.}}$	$\frac{I_{opt.}}{I_{électr.}}$
Données théoriques	1.32	0.98	1.30
Les résultats de la première série de mesurages effectués avec chauffage	1.23	—	—
Résultats de la seconde série de mesurages effectués avec chauffage	1.18	0.93	—
Résultats de la troisième série de mesurages effectués avec chauffage	—	—	1.13
Les résultats de 16 mesurages effectués à la température ambiante	1.25	0.93	—
Les résultats de 9 mesurages effectués à la température ambiante avec chauffage préliminaire du cristal	1.18	0.99	1.16
Les résultats de la première série de mesurages effectués sur le second échantillon avec chauffage	1.17	1.02	1.19
Les résultats de la seconde série de mesurages effectués aur le second échantillon avec chauffage	1.09	1.02	1.11
La moyenne des mesurages	1.18	0.98	1.14

Dans la première colonne on donne le rapport de l'intensité de la lumière $I_{méc.}$, dispersée par l'échantillon, lorsque l'axe mécanique est dirigé perpendiculairement au plan de la dispersion, à l'intensité de la lumière $I_{électr.}$, dispersée lorsque c'est l'axe électrique qui est dirigé perpendiculairement au même plan.

Par conséquent, nos mesurages prouvent d'une manière sûre l'effet de l'anisotropie de l'intensité de la direction et de l'ordre, prédit par la théorie.

Quant à la comparaison quantitative avec la théorie elle n'est possible, pour le moment, que sous certaines reserves.

Il faut tenir compte de ce que les mesurages étaient effectués en lumière blanche. Par conséquent, de même que l'intensité de la lumière dispersée par les fluctuations calorifiques ($I_{fluct.}$), l'intensité de la dispersion combinée ($I_{comb.}$) joue également un rôle. La méthode d'étude de la relation entre l'intensité de la lumière dispersée et la température permet d'éliminer l'influence des effets accidentels, mais non de la dispersion combinée, car l'intensité de cette dernière dépend aussi de la température, quoique suivant une autre loi, que l'intensité de la dispersion de Rayleigh. Le fait que l'expérience donne une relation linéaire entre l'intensité totale ($I_{fluct.} + I_{comb.}$) et la température est probablement le résultat d'une combinaison complexe des différentes variations de températures pour les satellites stokesiens et anti-stokesiens, ce qui a besoin d'une étude spéciale supplémentaire. Ce qui

est essentiel pour la question de l'anisotropie de l'intensité, c'est que l'intensité totale de la dispersion combinée est indépendante de l'orientation du cristal; les mesurages récents effectués par Michalke [5] le confirment. Pour cela, avant de comparer les résultats obtenus par la théorie, il faut soustraire de la valeur de l'intensité totale la valeur de l'intensité de dispersion combinée ($I_{comb.}$). Malheureusement, pour l'instant, on ne possède pas les données suffisantes relatives à l'intensité de tous les satellites de quartz. D'après les mesurages de G. S. Landsberg et M. A. Leontowitch [4] et les données sémi-quantitatives d'autres savants [6], nous pouvons approximativement évaluer la valeur de l'intensité $I_{fluct.}$.

En introduisant le correctif indiqué, nous obtiendrons les données de l'anisotropie de l'intensité (tableau 2).

Tableau 2

	$\frac{I_{méc.}}{I_{électr.}}$	$\frac{I_{opt.}}{I_{méc.}}$	$\frac{I_{opt.}}{I_{électr.}}$
Données théoriques	1.32	0.98	1.30
Moyenne des mesurages avec le correctif de la dispersion combinée	1.33	0.98	1.26

Comme on voit, les résultats coïncident assez bien avec les données théoriques. En tenant compte du caractère préliminaire de l'évolution de l'intensité des satellites de dispersion combinée, nous pouvons considérer cette coïncidence comme tout à fait suffisante.

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PHYSICS

β-RAY SPECTRUM OF RaC AND ENERGY LEVELS OF EXCITATION OF RaC' NUCLEUS

By A. I. ALICHANIAN and S. J. NIKITIN

(Communicated by A. F. Joffe, Member of the Academy, 26.VII.1938)

The continuous β-ray spectrum of RaC, as originally suggested by Ellis and Mott (1), is a complex one, consisting of a number of elementary β-ray spectra with different values of upper limits. In analysing the spectrum of the β-rays emitted at the transition by RaC.C', Ellis and Mott came to the conclusion that β-disintegration of RaC causes transition not to the ground level, but to the excitation levels of RaC' nucleus (table).

To each of these transitions corresponds an elementary β-ray spectrum which enters into the continuous β-ray spectra of RaC. The latter thus contains five elementary spectra. The values of the upper limits of energy of these spectra are given in the table.

Excitation energy in MeV	Excitation probability	Upper limit energy of elementary spectra	Electron percentage
0.610	0.58	3 200	58
1.670	0.06	2 140	6
2.140	0.06	1 670	6
2.700	0.12	1 110	12
2.880	0.18	930	18

In constructing a total β-ray spectrum of RaC, Ellis and Mott assumed that the elementary β-spectrum has a shape similar to that of RaE spectrum, the disintegration of which is accompanied by no γ-radiation. Using the data of very rough measurements of Sargent, made by the absorption method, Ellis and Mott concluded that their β-ray spectrum of RaC agrees with the experimental one, thus confirming Ellis' scheme of RaC' nuclear levels.

It seems to us that in applying such a method of analysis it is impossible to obtain anything like a correct shape of the β-ray spectrum and it is necessary therefore to analyse once more the RaC spectrum using spectral curves, obtained by a more reliable method.

For this purpose the β-ray spectrum of RaC was studied within the range of 300—3175 ekV by the magnetic focussing method. Fig. 1 shows the results

of measurements. From 1600 ekV the ordinates of the curve decrease markedly with the increase of energy.

In decomposing the RaC spectrum into a series of elementary spectra we made use of the fact that the shape of the β-ray spectrum is, as repeatedly stated, perfectly described by the well known Uhlenbeck and Konopinsky equation, provided the upper limit of energy is taken to be the extrapolated value, obtained by Curie, Richardson and Paxton's method. An $U-K$ curve (Fig. 2) was plotted from the experimental data and a value of $W_0=9.51$ was obtained therefrom.

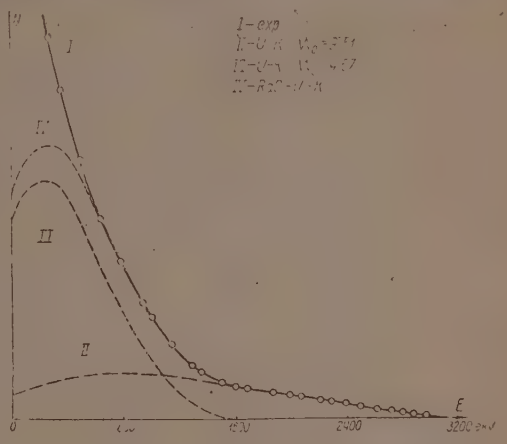

Fig. 1.

From this value (Fig. 1, curve *II*) a theoretical spectrum was constructed.

The theoretical spectrum thus obtained was subtracted from the experimental one and a residual spectrum having the upper limit of $E_0=1600$ ekV was obtained. A similar analysis of the residual spectrum has shown that the latter consists of two spectra, the upper limits being $E_{01}=1600$ ekV and $E_{02}=680$ ekV.

The second spectrum is the β-ray spectrum of RaB. Thus, the above analysis shows that the β-ray spectrum of RaC consists of two elementary spectra

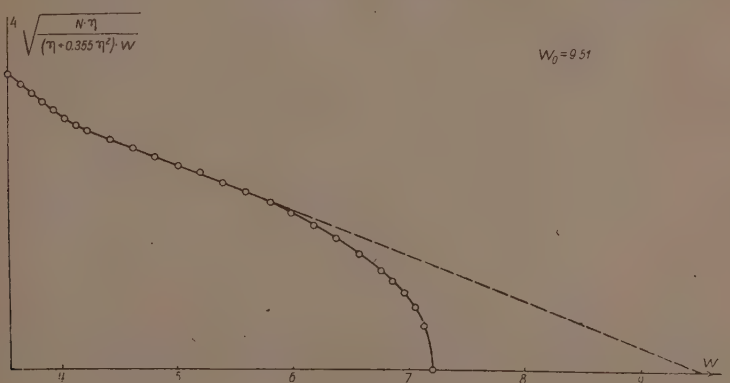

Fig. 2.

with the upper limits of 3175 and 1600 ekV, moreover 32.5% of all electrons correspond to the region of the hard spectrum, while the remaining 67.5% appertain to the β-ray spectrum with the upper limit of 1600 ekV. According to Ellis and Mott, however, the relation is reversed, i. e. the hard spectra have 65% of all RaC disintegrations and the remaining β-ray spectra have 35%.

Thus, the statement of Ellis and Mott that β-ray disintegration causes a transition to the levels of 1.67, 2.70 and 2.88 MeV fails to be confirmed by the present work.

Bothe and Maier-Leibnitz [2], who have studied the coincidences between β-rays and electrons emitted by RaC, also failed to establish the existence of the 1670 ekV level, nor did they reveal the 0.61 MeV level. This led them to conclude that RaC disintegration causes a transition to the ground level, which corresponds to the β-ray spectrum with the upper limit of 3175 ekV.

Further on, the above writers pointed out sharp variations in the spectral curve near 1600 ekV, which is in conformity with the present results.

Thus, both the direct observation of coincidences of γ-rays with separate regions of the β-ray spectrum of RaC and the analysis of this spectrum fail to confirm the scheme of RaC' levels, constructed by Ellis on the basis of a great number of γ-lines and long range α-particles, emitted by this nucleus.

This conclusion is the more surprising to us as not only the previously known γ-lines, but also the hard γ-lines newly revealed by A. Alichanov and G. Latyshev [3] are satisfactorily accounted for by the Ellis scheme.

In addition we have investigated the spectral distribution near the end of the RaC spectrum and have found in this case too, as well as in the case of RaE and ThC spectra, a sharp deviation from the Uhlenbeck-Konopinsky distribution. Fig. 2 shows a $U-K$ plot of the end of the RaC spectrum from which it is seen that starting from $W = 5.8\ m_0 c^2$ energy, the number of electrons drops much sharper than this should be expected from the Uhlenbeck-Konopinsky theory for $\mu = 0$.

The attempt to ascribe a finite mass to the neutrino brings us, as shown in our previous paper [4,5], to a paradoxical result, while from the RaE spectrum $\mu \approx 0.3\ m_0$, and from ThC spectrum $\mu \approx 0.8\ m_0$, a preliminary evaluation based on the RaC spectrum gives $\mu \approx 2\ m_0$.

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PHYSICS

SIMPLE APPLICATIONS OF THE PROCA POTENTIAL

By D. IWANENKO

(Communicated by S. I. Wawilow, Member of the Academy, 10.VIII.1938)

After various authors had advanced the hypothesis of the whole number value of the spin for the new particle of the mass $m_a = 100—200\ m_{e}$* [1], the equations of Proca proved a consistent scheme for their description. It seems desirable to trace in detail the possible energy transfer between neutron and proton by these semi-heavy particles, since the interaction through particles with half-valued spin is essentially like the known theory of β-forces, which is connected with the supplementary neutrino hypothesis.

1. In the first place we would note that the somewhat cumbersome derivation [2] of the coupling between heavy particle and semi-heavy field can be avoided by means of the following considerations. As the Proca potential φ is quite analogous to the Maxwellian four-potential, we can write the required coupling in the habitual form of the electromagnetic perturbation energy, substituting only the electric charge by the quasi-charge g and introducing the operators Q of the transformation neutron-proton:

$$U_1 = g\,[\varphi_0 + (\alpha\varphi)]\,Q + c.\,c. \qquad (1)$$

or $U_1 = g\varphi_0$ in non-relativistic approximation. This scalar potential gives the nuclear interaction of the form:

$$V_1 = \frac{e^{-k_0 r}}{r} P_H; \quad k_0 = \frac{m_a c}{R},$$

P_H — operator of the Heisenberg's exchange.

2. On the other hand, the empirical data on deuteron require preponderantly the Majorana forces, which in a non-relativistic case can in no way appear from U_1. Exactly the same situation was already met with in the theory of β-forces [3], and it is evident that we need to introduce the new term of coupling of the form

$$U_2 = \mu\gamma_{\mu\nu} F_{\mu\nu} Q + c.\,c. \qquad (2)$$

or in non-relativistic approximation: $U_2 = \mu\,(\sigma H)$ where μ—is the intrinsic quasi-magnetic moment of a heavy particle, σ—its spin matrix, H—the quasi-magnetic part of the six vector of the Proca field. This latter term

* m_{e}—electron's mass.

is of the known Pauli-form and it may seem doubtful whether its introduction is reasonable, since (1) automatically leads to the quasi-magnetic moment of the heavy particle of the mass M of the magnitude:

$$\mu' = \frac{gh}{2Mc}.$$

But apart from the necessity of Majorana exchange, empirical data require a far greater value than μ', namely

$$\mu \sim \frac{gh}{m_a c} \sim \frac{m_a}{M}\mu'. \tag{3}$$

The Bartlett forces permit of an analogous treatment.

3. For lack of exact experimental data on the mass m_a of the new particle we find ourselves under the necessity to determine it from the comparison with the semi-empirical theory of deuteron. It should be noted that some simple theoretical considerations permit of giving the limit for this important constant. We require only the negative value for the total energy of the deuteron and apply first of all the virial theorem and the Bohr quantization, both of which give satisfactory results, as it can be verified by the quantum-mechanical treatment of the corresponding perturbed Schrödinger's equation or by means of the variational method (further analysis of which will be given elsewhere in collaboration with V. Roditshev). The viria theorem gives us the fundamental condition for $\alpha = k_0 r$:

$$\alpha < 1 \tag{4}$$

where r is the mean radius of the deuteron. Quantization yields the supplementary condition for the possibility of solution of a certain transcendental equation, from which one gets

$$\frac{m_a}{M} < 0.37 \cdot \frac{g^2}{hc}. \tag{5}$$

Now g^2/hc, which plays the same rôle of the fine-structure constant as the parameter of expansion, must in any case be smaller than unity (Heitler and collaborators assign it the value $^1/_6$). Hence, without any comparison with empirical data, on the mere ground of the hypothesis of the energy transfer by semi-heavy particles, we get the following reasonable upper limit for their mass $m_a < 680\ m_{el}$ which may be compared with the best experimental value available (Corson-Brode) $200 \pm 50\ m_{el}$, and with the highest value $m_a \sim 500\ m_{el}$ obtained by Nishina.

Quite unexpectedly, for the realization of Proca-Yukawa nuclear forces one can use only particles of a limited mass.

4. In view of successful explanation of nuclear interaction, it is perhaps not premature to ask about the self-interaction of heavy particles induced by the semi-heavy field. Although the problem of self-energy was not solved till now for any of known particles, we can say that the electron probably possesses a mass of electromagnetic origin since its electromagnetic radius $r = \frac{e^2}{mc^2}$ coincides as a matter of fact with its empirical dimensions. From this point of view the mass of a neutron, say, cannot be electromagnetic nor of β-nature, as these latter models both give a radius of the order of 10^{-16} cm instead of the required 10^{-13} cm. Is the mass of neutron-proton entirely semi-heavy? The most simple line of reasoning is the classical

method of introducing the radius of the particle. Constructing a surface and volume quasi-charged heavy particles we obtain for its self-energy:

$$E_s = \frac{1}{2} g^2 \left(\frac{1}{a} + k_0 \right) e^{-2k_0 a} ;$$

$$E_v = \frac{9}{4} \frac{g^2}{a^6 k_0^2} \left\{ \frac{2}{3} a^3 - \frac{1}{k_0} \left(a^2 - \frac{1}{k_0^2} \right) - \frac{1}{k_0} \left(a + \frac{1}{k_0} \right)^2 e^{-2k_0 a} \right\} . \quad (6)$$

respectively, both expressions tending to well-known classical formulae within the limit $k_0 = 0$. Putting $g = 5e$, $m_a = 200\ m_{el}$, one gets for the radius of a heavy particle an inadmissibly small value of the order 10^{-15} cm. We believe this result to be of importance, because all existing models of self-interaction [non-linear field theory, quantization of space in its primitive form of introduction of the minimum space-time interval (4), or in the new Born's form of postulating the maximum impulse] are but a more accurate and relativistically invariant formulation of the classical method of radius. The results obtained can be checked either by constructing simple non-linear generalizations of Proca equations (which is easier in this case than in the Born-Infeld theory, owing to the absence of gauge invariance), or by means of the Born invariant method of maximum impulse; in both cases the value found for the radius of a heavy particle will be of an inadmissibly small order. Thus, we cannot admit the hypothesis of semi-heavy nature of heavy mass, at least in its simple form.

We hope to return later to the question of equivalence of various models for self-interaction, which all introduce a new constant of length or a dielectric constant for vacuum different from unity. Both these methods are not so different as may be seen, since for instance the characteristic square root factor in the expression for the number of oscillations in Born's model of quantized space can be treated as due to the presence of a dielectric constant of the vacuum:

$$\varepsilon \sim 1 + \frac{\nu^2}{\nu_{\max}^2} .$$

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Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
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PHYSICS

ON THE NATURE OF THE HEAVY ELECTRON

By A. SOKOLOV

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The question as to the nature of the heavy electron which Neddermeyer and Anderson (1) believe to be constituent of the penetrating component of cosmic radiation remains so far unsolved. Recent data obtained by Blackett (2) have shown that heavy electrons become common ones as soon as their energy drops as low as $2 \cdot 10^8$ eV.

If we assume together with Yukawa (3) and Durandin and Ershow (4) the heavy electron to possess a whole number spin*, then the new particle should obviously be considered a complex one, as, for instance, consisting of an electron and a neutrino.

Let us choose the law of interaction between the heavy particle (which evidently «gives birth» to the heavy electrons) and the field of electrons and neutrinos in the following form:

$$g\Box^{-1} R(\psi^{+}\varphi)$$

where g is some constant, ψ and φ—wave functions of positron and neutrino, while R denotes the relativistic invariant combination of functions ψ and φ**. Then, with electron energies $E \gg mc^2$ (i. e., electron mass m being negligible) operator $\Box^{-1}$ leads to that, like in the neutrino theory of light (8), both particles (the electron and the neutrino) must fly together, forming thus a single particle, while with energies comparable to mc^2, a complex particle should disintegrate into elementary ones, i. e. the electron and the neutrino. The latter fact seems to be in good qualitative agreement with experimental data obtained by Blackett (2).

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* See also Heitler (5), Kemmer (6) and Bhabha (7) who succeeded in explaining nuclear forces and additional magnetic moment of a heavy particle by means of a spinless heavy electron.

** Various forms of the relativistic invariant combination R will be the subject of our next study.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
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PHYSICAL CHEMISTRY

THE KINETICS OF WETTING AND THE LINEAR-SELECTIVE CORROSION OF METALS IN POLYPHASE SYSTEMS

By D. I. MIRLIS and A. I. GLUCHOVA

(Communicated by Wl. A. Kistiakowsky, Member of the Academy, 16.VII.1938)

THE INFLUENCE OF HYDROGEN SULPHIDE ON THE PECULIARITIES OF THE CORROSION OF IRON IN THE SYSTEM Fe—WATER—BENZINE

Along with hydrogen sulphide cracking-benzines and press-distillates contain organic acids, aldehydes and especially acids of the fatty series. These substances are formed as a result of the spontaneous oxidation of the unsaturated hydrocarbon of the fuel, during which peroxides are formed, which in their turn give origin to organic acids and other compounds (1). In order to find the general regularity of the corrosion of the metal container, in which liquid hydrocarbon fuel is kept under the action of the substances named above, and in order to discover some means of protecting metal reservoirs from corrosion, experiments were conducted to find the degree of aggressiveness of each of the constituents in benzine.

In former works one of us (1) studied the aggressive rôle of individual acids of the fatty series in homogeneous and polyphase systems in relation to the metals Fe, Al and dur Al, and as depending on the length of the chain. The experiments were conducted with pure benzene and with benzine obtained from direct distillation after profound purification. This investigation revealed a number of regularities of both theoretical and practical importance.

This work is a further development of Kistiakowsky's (2) and our (3) works on the corrosion of metals in polyphase contact and its purpose is to study the influence of hydrogen sulphide on the peculiarities of the corrosion of the iron in the polyphase systems: Fe—water—benzine, separately in each phase and at the interfaces between the phases.

In studying the influence of hydrogen sulphide on the kinetics of wetting and on the linear-selective corrosion of iron in the system Fe—water—benzine (direct distillation) we made use of the method devised and described by one of us in preceding papers (3).

In accordance with this method the objects used for the test were of rod-iron* which we have used in all our experiments in former works. The hydrocarbon liquid which we used was benzine of direct distillation after

* The iron was of the following composition: Si—0.047%, S—0.01%, Mn—0.15%, C—0.01%, P—0.011%.

Table 1

Medium and conditions of experiment	Corrosion of iron in time, days	General average loss of iron in time, mg		Average loss Fe in mg per 1 cm² surface		Relative value of corrosion in %		Nature of the corrosion of iron in the phases and at the interface		
Equilibrial systems		in the aqueous phase	in the benzine phase	in the aqueous phase	in the benzine phase	in the aqueous phase	in the benzine phase	in the benzine phase	in the aqueous phase	the interface between the phases
Fe—saturated aqueous solution H_2S—benzine . .	15	29.1	255.0	4.63	40.6	6.5	39.7	A thick layer of corrosion products forms on the metal	A loose black coating of iron sulphide which increases with time forms on the metal	The effect of linear corrosion is faint
Fe—saturated aqueous solution H_2S—benzine . .	60	448.4	642.4	71.4	102.2	100	100	As a result of inversion of selective wetting, droplets of an aqueous solution form on the surface of this hydrophylic layer		

profound purification. The experiments were conducted in glass cylinders. The Fe samples were hung on glass hooks so that one half of them was submerged in a saturated aqueous solution of hydrogen sulphide, and the other half in benzine, while the joint between the two halves was in the phase of least intensive corrosion.

In order to study corrosion in homogeneous mediums we submerged the metal entirely in a solution of H_2S in benzine (surface contact).

According to our method 10 identical samples were submerged at the same time under the same conditions, and were taken out at definite intervals (15, 30, 60 days, etc.), then the peculiarities of the corrosive process were characterized qualitatively. If the metal had resinous substances on it, it was cleaned with alcohol. The corrosion products were removed with a mixture of the following composition: 2 g $SnCl_2$+5 cm³ of 5% formaline+5 cm³ hydrochloric acid (2° Be)+100 cm³ H_2O.

The kinetics of the corrosion process in the system Fe—aqueous solution H_2S—benzine was studied alongside with this after Mirlis and Rehbinder's method (4). The results of this investigation are summarized in Tables 1 and 2.

Following the source of the corrosive process in relation to time in the experiments given in

Table 1, we may notice that in the aqueous phase corrosion goes on as usual, forming a continous friable layer of corrosion products on the metal (FeS and other compounds). The formation of the sulphide film in the aqueous medium and its destruction are a very rapid process. In the benzine phase the iron becomes coated with a goldish film in the first minutes, but after 15 minutes the sulphide film may already clearly be seen to hydratize. In 12—15 hours after the beginning of the experiment the surface of the iron becomes coated with a layer of blackish-brown coloured corrosion products. A new phase in the form of droplets of an aqueous H_2S solution forms on the whole surface of the hydrophylic film which formed on the iron in the benzine phase (see Graph 1). Thus, we get the following systems: Fe—$FeS.Fe_2O_3$ aq—benzine and Fe—$FeS . Fe_2O_3$ aq—water H_2S solution—benzine. In time these droplets become filled with corrosion products and change into a hydrated gel of iron hydroxide. Afterwards this gel dries up and falls onto the interface.

In the place formerly occupied by the droplets there appears a figure shaped somewhat like a calyx. After 15—60 days the sulphide film, which has thickened into a «coat» in hydrocarbon medium, can be easily taken off the metal while it retains the form of the sample (Fig 1, *a* and *b*).

Corrosion in the presence of hydrogen sulphide is much more intensive in the benzine phase of the polyphase system studied by us, than in the aqueous phase. At the interface, the effect of linear-selective corrosion is but very faintly expressed (hazy). In the system Fe—water—benzine, where there is no hydrogen sulphide, the effect of linear-selective corrosion is, on the other hand, more pronounced.

The thickening of the sulphide film and the formation of a «coat», which separates easily from the sample under test, can be brought about with adequate inlet for oxygen of the air; in the opposite case, the corrosion products formed (the thickened sulphide film) fall to pieces, as we have already noted, and cannot be taken off normally from the metal sample tested. The initial stage of the corrosion process can be schematically explained as follows.

Fig. 1

a — sulphide film thickened in hydrocarbon medium, copying the shape of the sample; *b*—nature of the corrosion process in the system Fe—water solution H_2S—benzine.

The aggressor (an aqueous solution of H_2S) is admitted into the hydrocarbon phase from the aqueous phase, and is adsorbed on the metal, changing the nature of the latter's surface in hydrophylizing (as a result of corrosion) and thickening the original sulphide film. This contributes to the inversion of the selective wetting and absorption of water from the aqueous phase, which then turns into droplets. We observed an analogous effect ([1]) in the system Fe—aqueous solution CH_3CH_2COOH $n/_1$—benzine. However, since the corrosion products are soluble, corrosion proceeds chiefly on the metal, the effect of linear-selective corrosion being particularly well pronounced along the perimeter of the droplets, which distinguishes this system from that studied in the given investigation.

In studying the mechanism of the thickening of the sulphide film in the system Fe—aqueous solution H_2S—benzine we took into account (as

one of the factors) Dunlap's view on the question (5). FeS being a dehydrating agent, Dunlap assumed that iron sulphide must react with the saturated hydrocarbons according to the following scheme:

$$FeS + RCH_2 - CH_2R \rightarrow RCH = CHR + Fe + H_2S.$$

Under our experimental conditions in the presence of the oxygen of the air and moisture, ferrous and ferric hydroxide, and also a very small quantity of resin which deposits on the metal in the phases, form along with iron sulphide and other iron compounds.

The corrosion products also contain elementary sulphur in small quantities.* Dunlap supposes that the unsaturated compounds formed oxidize and

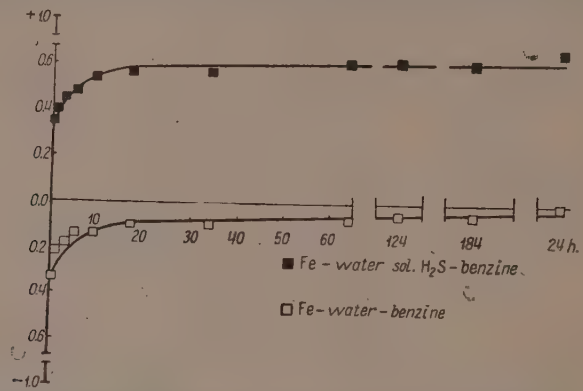

Fig. 2. Influence of hydrogen sulphide on the kinetics of wetting and the effect of linear-selective corrosion of iron at the boundary-line between the phases.

give origin to peroxide compounds; these must probably also do their part in forming the continuous coating of corrosion products, as «cementing substances» (resins). The statements advanced require, however, further evidence, since Dunlap's experiments were conducted at higher temperatures.

We studied the hydrophylization of the surface of iron in the system Fe—water—benzine quantitatively in the presence and in the absence of hydrogen sulphide, by measuring the edge angle of wetting (Θ_{12}) in time (4).

$$B_{12} = \cos \Theta_{12}$$

Table 2

Time in minutes, τ	Fe—water—benzine		Fe—saturated aqueous solution H_2S—benzine	
	Θ_{12}	B_{12}	Θ_{12}	B_{12}
0	109	—0.326	88	+0.035
1	103	—0.225	66	+0.407
3	101	—0.191	63	+0.454
5	98	—0.139	61	+0.485
9	98	—0.139	57	+0.545
17	96	—0.105	55	+0.574
34	96	—0.105	55	+0.574
64	94	—0.070	51	+0.629
124	93	—0.052	50	+0.643
134	92	—0.052	50	+0.643
24 hrs	90	0.000	46	+0.695

* Sulphur deposition may possibly be connected with the intense oxidation of hydrogen sulphide by peroxide compounds.

Table 2 and the wetting diagrams corresponding to it show that if hydrogen sulphide is present in the system under investigation (Fe—water—benzine), the hydrophylization of the iron surface is more pronounced than if hydrogen sulphide is absent. This fact supports our scheme of the mechanism of a new phase formation in the shape of droplets of an aqueous solution on the iron surface in benzine ([6]).

The corrosion process is entirely different under the conditions of polyphase contact in the cracking-benzines and press-distillates, which contain, along with hydrogen sulphide, the surface-active impurities noted above (especially acids with long chains of carbon atoms). In this case corrosion is greatly slowed down in the phases which is due to the formation of a chemically fixed adsorption layer of surface-active substances on the surface of the metal ([4,6]). It is of great interest that in a number of cases the anticorrosive properties of the adsorption layer on the metal become intensified in the presence of hydrogen sulphide.

Our study of the part played by surface-active substances in the corrosion of metals in the system metal—water—benzine will be the subject of a special communication.

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Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XXI, № 1—2

CHIMIE PHYSIQUE

L'ACTION DE CO_2 SUR L'AUTO-INFLAMMATION DU MÉLANGE HEXANE—AIR

Par W. STERN, B. KRAVETZ ET A. SOKOLIK

(Présenté par N. N. Semenov, de l'Académie, le 25.VII.1938)

Notre étude de l'auto-inflammation dans mélanges pentane—air aux retards courts (1) a abouti à l'hypothèse de l'action ralentissante des produits finals d'oxydation (CO_2, H_2O) sur la réaction préflamme, comme la cause de la non-variabilité du retard d'inflammation dans la zone supérieure des températures (400—600° C).

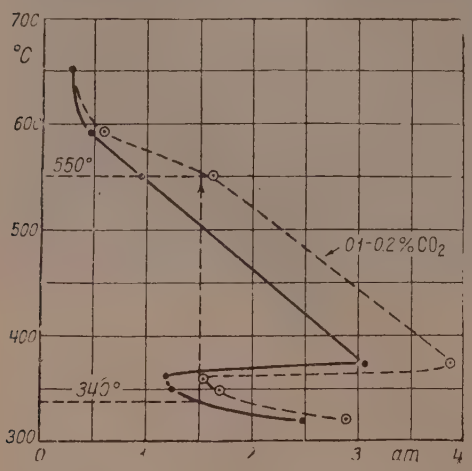

Fig. 1.

Pour vérifier cette hypothèse nous avons entrepris l'étude de l'action des produits différents d'oxydation sur l'auto-inflammation du mélange hexane—air (3.5% C_6H_{14}). Nous avons utilisé la méthode décrite de l'enregistrement du retard d'inflammation en introduisant un nettoyage plus minutieux de la bombe à explosion, ce qui assure la reproduisibilité suffisante des résultats.

Or, nous avons constaté une augmentation considérable de pression limite (P_{lim}) causée par les quantités minimes de CO_2 (1—$2 \cdot 10^{-3}$ mol.). Nous avons reproduit exactement cet effet dans une série considérable d'expériences consécutives avec le mélange pur d'hexane—air et celui avec l'addition de CO_2.

L'auto-inflammation disparaît même quand il y a des traces de CO_2 qui restent dans la bombe préalablement remplie de CO_2 et ensuite évacuée par la trompe à l'huile.

On voit sur la fig. 1 que l'addition de CO_2 déplace toute la zone d'inflammation vers les plus hautes pressions.

Ainsi, l'action de CO_2 est tout à fait analogue à celle de $PbEt_4$ et tout

à fait contraire à l'action d'acetaldehyde, qui, selon les expériences de Townend et collaborateurs[2], fait baisser les pressions limites.

Dans un intervalle étroit de pressions 0.1% CO_2 cause une augmentation considérable de la température d'auto-inflammation—de 340 à 550° C. Ceci est aussi analogue à l'action de $PbEt_4$ [voir les données de Townend et Cohen[2]].

L'action de CO_2 est plus nettement exprimée dans la zone des températures basses et presque disparaît avec des températures au-dessus de 550° C. Notons que les retards d'inflammation restent invariables dans les mêmes limites de températures (de 350 à 590° C) et diminuent legèrement avec l'augmentation ultérieure de la température.

L'addition de CO_2 en plus fait augmenter les retards d'inflammation ce qui est illustré par des données numériques dans le tableau suivant:

T=320°, P=3.14 atm.

% CO_2	0	1	5	9
Secondes	1.1	1.25	1.75	1.4

T=590°, P=0.9 atm.

% CO_2	0	0.9	1.8	4.5	9
Secondes	0.7	0.9	0.7	1	1.1

T=590°, P=1.75 atm.

% CO_2	0	0.5	1	2	3	4.5	9
Secondes	0.3	0.4	0.7	0.5	0.5	0.5	0.4

Comme on voit du tableau ce ne sont que de petites concentrations de CO_2 (jusqu'a 5%), qui donnent l'augmentation du retard d'inflammation comme résultat de l'effet ralentissant dans les réactions préflammes. Les quantités de CO_2 plus considérables causent au contraire une diminution des retards, ce qui, probablement, se rattache à l'action connue de la dilution par les gaz inertes, accélerant les réactions à chaînes dans la période préflamme.

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Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1938. Volume XXI, № 1—2

BIOCHEMISTRY

ISOLATION OF THE ENZYME TRANSFERRING THE AMINO-GROUP OF GLUTAMIC ACID

By M. G. KRITZMANN

(Communicated by A. N. Bach, Member of the Academy, 3.VIII.1938)

The intermolecular transfer of amino-groups from glutamic acid to α-keto-acids, recently discovered in muscles and other animal tissues by Prof. A. E. Braunstein and the author, is due to a specific enzyme the author succeeded to isolate and purify to a certain extent in the following way (the procedure will be described in more detail in a forthcoming paper).

I. Minced pigeon muscles or pig heart are washed with tap water, ground with sand, extracted with 1% $KHCO_3$ solution and squeezed through cheese cloth. After incubation at 37° for 30—60 minutes, the turbid extract is acidified to pH=4.5 with acetic acid. The precipitate is centrifuged and thoroughly washed with distilled water. The precipitate *A* suspended in phosphate buffer solution (pH=7.5—8.0) is highly active. Dry preparations obtained by rapid drying of precipitate *A* in vacuo over P_2O_5 retain full activity after two month's storage. Dehydration with acetone, ethanol or methanol completely inactivates the enzyme.

II. From suspensions of precipitate *A* in phosphate buffer water-clear enzyme solutions can be obtained in several ways, e. g. by filtration through a porous alundum filter cylinder (filtrate *B*).

III. From filtrate *B* the enzyme is separated by means of $(NH_4)_2SO_4$, redissolved in water, dialysed and made up with phosphate buffer (solution *C*).

Solution *C* is fairly stable when kept at 0°.

Up to this stage 98% of the inactive material present in muscle tissue are removed, i. e. a 50-fold degree of purification is achieved.

The enzyme is active within a wide range of hydrogen ion concentrations (pH=5.5—9) with a marked optimum near pH=7.5. Heating to 70° for 20 minutes (at pH=7.5—8.0) causes no significant loss of activity, while 20 minutes' heating to 85° results in 85—90% inactivation.

Glutamic acid and other aminoacids are not metabolized by the enzyme (even with the addition of muscle «Kochsaft») and do not yield ammonia. Likewise, the α-ketoacids, including α-ketoglutaric acid, do not undergo any chemical change in its presence, and no aminoacid synthesis is observed from α-ketoacids or ammonia. Upon simultaneous addition of glutamic acid and an α-ketoacid (or of an aminoacid + α-ketoglutaric acid) a rapid transfer of amino nitrogen ensues.

The following fact is remarkable: minced muscle tissue readily transfers

nitrogen from both glutamic and aspartic acids (resp. to α-ketoglutaric and oxaloacetic acids). As opposed to this, our enzyme preparations (beginning with precipitate *A*) are completely inactive with regard to aspartic or oxaloacetic acid, though highly efficient in catalyzing the «Umaminierung» of glutamic acid (resp. α-ketoglutaric acid). It follows that the «Umaminierung» of the C_4- and C_5-dicarboxylic acids respectively is due to different, though possibly closely related, enzyme systems. Further work on the isolation of the aspartic acid enzyme is in progress.

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BIOCHEMISTRY

AGE AND DAILY VARIATIONS OF CITRIC ACID CONTENT IN LEAVES OF *NICOTIANA RUSTICA*

By A. V. VLADIMIROV and G. V. LIASKOVSKAJA

(Communicated by D. N. Prianishnikov, Member of the Academy, 11.VIII.1938)

Up to not long ago lemon was almost the only source to produce citric acid on industrial scale. This circumstance greatly enhanced the cost of citric acid production. Within these latter years, however, cheaper and easier methods have been established to obtain citric acid. The works of Amelung (7), Bernhauer, Kostytschew, Wetzel and especially the last works of Butkevich (1,5,6,11) have proved the possibility of obtaining citric acid from carbohydrates by subjecting the latter to the action of molds and yeast fungi *(Ascomycetes)*.

On the other hand, A. A. Shmuk (2) and associates have elaborated a method to obtain citric acid from *Nicotiana rustica* on industrial scale. The content of citric acid in *Nicotiana rustica* amounts to 10% and more of dry mass and is moreover easy to separate from the plant, which therefore becomes a most valuable raw material for the large scale production of citric acid. As technical crop *Nicotiana rustica* can, thus, be turned to account not only for smoking, but also in the industry of citric acid and nicotine (3).

Availing ourselves of different means to influence the growth and development of *Nicotiana rustica*, we shall be able to increase the content of the above products in it and raise the value of this crop. The content of citric acid may, for instance, be enhanced by suitable mineral supply, different ways of pruning, reasonable dates of harvesting and drying. The aim of the present work is to clear up the question of how the conditions of storing of citric acid in the leaves of *Nicotiana rustica* are influenced by the time of harvesting.

As established by the experiments of A. I. Smirnov (4), the content of organic acids in tobacco goes up with the age of the latter. On the one hand, pH in the water extract from the leaves, on the other, ash content and alkalinity have been estimated by this author, who has found the total ratio of organic acids to increase with the development of leaves. In tobacco leaves approaching maturity the total content of organic acids has appeared to be notably greater than in young and unripe ones (4).

As to daily variations of the content of organic acids in plants having the same age, the works of Bennet-Clark (8,12), Richards (9), Kraus and others have shown it to be greater by night than by day.

Thus, as regards the total ratio of organic acids in plants, its age and daily

variations have been more than once discussed in literature and there are sufficient data bearing on the subject.

Yet, the storing of separate organic acids, citric acid in particular, in plants which are so rich in it as *Nicotiana rustica* is, has been studied, but scarcely and we find no literature concerned with this question.

Therefore, in the experimental part of this preliminary work we set ourselves the task to produce age and daily variations of the content of citric acid in the leaves of *Nicotiana rustica*, with the aim to put the question as to the time of harvesting of this plant on physiological ground and to secure a maximum content of citric acid in it.

In 1936 we set up a field experiment with *Nicotiana rustica*, variety Pekhletz. The samples for analysis were taken during vegetation at the following dates: July 5, July 25, August 5. Each of these three ages was represented by four samples taken at different time within 24 hours, viz. at 1 h. 30, 60 h. 30, 13 h. 30 and 20 h. 30. The method apllied was as follows. Two leaves were taken from each plant: the 5th and the 6th one from below. Being cut off, the leaves were immediately put into an exsiccator with ether and kept in ether vapour for conservation during 30 minutes. Thereupon the samples were transferred into thermostat and remained there at 60—65° C until they had become thoroughly dry; then, reduced to powder, they were put into jars provided with ground-in stoppers. In that condition they were waiting the analyses.

The samples were analyzed for the content of citric acid and nicotine.

Citric acid was estimated by volume ([10]) (precipitated as pentabromacetone and treated subsequently with alcohol and alkali; back titration with acid).

Nicotine was estimated by volume after the modified method of Keller.

The figures obtained from analysis have been recalculated in per cent of the dry weight of the leaf.

The results are summed up in Table 1.

Table 1

Age and Daily Variations of Citric Acid Content in Leaves of *Nicotiana rustica* (in % of dry matter)

Date of sampling	Ratio of citric acid within 24 hours			
	1 h. 30	6 h. 30	13 h. 30	20 h. 30
July 5	1.24	0.91	0.55	0.84
July 25	2.57	2.48	0.79	0.98
August 5	3.59	3.01	0.93	1.27

In this table we see the figures to increase with the age of plant.

Comparing the ratios of citric acid within 24 hours of the same day, we find the higher values in the columns of night and morning hours.

In contradistinction to citric acid carbohydrates (sugars) are known to raise their content by day, so that there is a reverse dependence between the ratios of citric acid and carbohydrate. This circumstance suggests the idea of the carbohydrates transforming into citric acid during night and morning, when the oxidation processes are prevailing in plant, which is moreover supported by the last works of Butkevich ([5]) who has observed a formation of citric acid in the leaves of *Nicotiana rustica* from the glucose introduced by vacuum-injection.

Thus, our experiment with conserved material, which has essentially been preserved from fermentation, has established that the ratio of citric

acid grows with the age of *Nicotiana rustica* and thereby is subject to notable rise in the night and morning hours. But in what degree does the change in the content of citric acid in course of 24 hours manifest itself when the leaves are kept under usual conditions (drying without conservation)?

In order to solve this question we undertook another experiment in 1937. It had for object to reveal the content of citric acid in the leaves of *Nicotiana rustica* cut off at different hours of the day and dried under the conditions prevailing in practice. Variety Egorka has been subjected to test. The samples were taken during vegetation at two dates—August 17 and October 1.

At each of these days we took the samples two times within 24 hours: at 1 o'clock and 13 o'clock. The 3d, 4th and 5th leaf from below were removed from each plant. In all, 36 leaves from 12 plants, for each of the samples. A half of each sample underwent conservation in ether vapour for 30 minutes and then was dried in a thermostat at 60—65°. The other half was treated according to the usual procedure.

The data obtained in this experiment as to the content of citric acid are summarized in Table 2 (in % of dry matter)*.

Table 2

Date of sampling	Laboratory treatment		Usual treatment	
	1 h.	13 h.	1 h.	13 h.
August 17	2.32	1.94	3.38	2.12
October 1	2.12	1.82	2.83	1.96

The data show that regardless of treatment the content of citric acid is greater in the leaves gathered by night. The difference between the usual and laboratory variants is also in favour of this time.

From the experiments referred to one may conclude that the content of citric acid in the leaves of *Nicotiana rustica* obtains its maximum in the night and morning hours and that being promoted by the process of drying it enjoys a further increase in the harvested leaves both absolutely and in comparison with the leaves gathered by day.

It follows from what has been stated above that the time of harvesting *Nicotiana rustica* should be differentiated according to the purpose of its cultivation.

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* The tests have been done by M. G. Zhukova.

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PETROGRAPHY

SHOWINGS OF RARE METAL MINERALIZATION IN THE SOUTH-EASTERN PART OF MOUNTAINOUS ALTAI

By G. D. AFANASSIEV

(Communicated by F. Loewinson-Lessing, Member of the Academy, 27.VII.1938)

The ore resources of Mountainous Altai give rise to considerable discussion. This controverse is mainly due to the fact that Mountainous Altai has so far been but insufficiently studied. The results of recent geological investigations have shown that the current assumption as to the poor mineral resources of Mountainous Altai is to be reconsidered (1). However, the reasoning of Nekhoroshev (2) and the conclusions grounded thereupon as to the concentrated polymetallic mineralizatoin in the Mountainous Altai, being scarcely probable in the future, remain the fundamental working hypothesis until a more thorough study of this region is achieved. At the same time it should be taken into account that within the area of Mountainous Altai too zones of tectonic subsidence may be discovered which are rather analogous to the zones of contortion of the Rudny Altai.

Mercury deposits (Chagan-Uzun) and (to a lesser extent) W and Mo deposits are known in Mountainous Altai. Showings of rare metal mineralization have been encountered within the zones of tectonic subsidence of Mountainous Altai, which evidently corresponds to the southern extremity of the lake Telezk rift valley (developed westward from the lake), referred to by a number of geologists.

The tectonically depressed zone investigated by the author occupies the area between the Bashkaus and Chulyshman rivers from Ulagan almost to the upper part of these rivers, about 2000 km² on the whole.

The geological structure of this area is characterized by a development of Middle and in part probably Upper Paleozoic sediments. According to the fauna discovered, one of these series is referred to the upper portion of the Middle Devonian. In the southern part of the region under investigation a thick monotonous belt of greyish-green, less frequently violet-coloured schists is developed with horizons of massif rocks. Our study showed that this belt is largely composed of metamorphozed quartz porphyry, porphyrites, keratophyres and tuffites lying among phyllites and arenaceous schists.

The peculiarity of the petrographic composition of this belt with regard to the general geological structure of the area does not altogether exclude its being referred to the Devonian age, though the Silurian seems to be more probable. According to recent data, a nearly analogous belt of Rudny Altai has been referred to the Devonian (3).

The complex of the Middle Paleozoic rocks forms a contact along the tectonic lines with crystalline schists of the Kurai range in the south-west and with the gneissic band of the Kara-Kem river in the north-east. The lines of disturbance, occasionally well pronounced, have a strike to the north-west within the azimuth range 300—320°. Aside from the principal north-western tectonic lines, zones of fracture with a north-western strike are developed over the very area lying between the rivers.

Intrusive igneous rocks are represented by three groups: I) basic serpentine rocks, «listvenites», etc.; II) granodiorites, diorites, diorite gneisses, gabbro-norites and plagiogranites, closely approaching to trondnjemites; III) biotite porphyry-like granites with vein derivatives (gabbro-diorites, pegmatites, etc.).

The porphyry-like granites of the III group are represented dy intrusive domes and are manifested on the surface within the tectonic subsidence. The area of separate intrusives is not very extensive and of variable size; the latter largely depends on the degree of denudation. The discordance of these domes with the contorted Middle Devonian rocks is quite characteristic. The age of the porphyry-like granites is definitely established as being younger than that of the Middle Devonian deposits. It is uncertain whether the upper boundary will be beyond the transition of the Paleozoic and the Mesozoic. Zones of sulphide-arsenic impregnation are related to porphyry-like granites. The rare metal mineralization is also genetically connected with these.

The manifestations of rare metal mineralization are shortly described below.

The Cobalt-Nickel Mineralization. The area of serpentine development at Kavaktaiga, where sulphides and other nickel minerals have been discovered in zones of hydrothermal alteration, is of some interest with regard to nickel. Besides nickel accompanies cobalt in mineralization of the arsenic type, connected with the porphyry-like granite intrusions. The cobalt mineralization is developed in the belt of mineralization depending upon the domes of porphyry-like granites emerging to the surface along the southern tectonic line.

The cobalt (nickel) mineralization is developed in zones of hydrothermal alteration of schists up to 1—2 m thick impregnated with sulphoarsenides Co and Ni.

Ore minerals: cobaltite, smaltin (?), erritrin, annabergite, chalcopyrite, arsenopyrite, ilmenite. Associated minerals: ankerite, quartz, chlorite, tourmaline, fluorite, scapolite, actinolite, biotite, muscovite and apatite.

Zones of hydrothermal alteration with cobalt minerals lie conformably with the enclosing schists, the latter being usually quartziferous, carbonatized and amphibolized or muscovitized in such zones. The cobalt content in specimens from surface outcrops varies from 1.5 to 0.02%.

Showings of cobalt mineralization have been encountered in two points along the right hand bank of the Bashkaus river: 1) near the Maly Ulagan river, 2) near the Atuurgol creek 22 km up the Bashkaus river from the first point. 50 km more up the Bashkaus river cobaltite has been found as an accessory mineral in the pegmatite granites of the Tokpak dome, where the geologist K. V. Radugin has established the presence of white marble blocks with cobalt colours.

The arrangement of the above points back our opinion as to the linear development of the cobalt mineralization, but at the same time it should be taken into account that the cobalt mineralization has been referred to the Meso- or even hypothermal type (comparatively little removed from the intrusion). The finding of new points should rather be expected in the aureo-

les of considerably eroded intrusives, within zones of disturbance to which they are confined.

The practical importance of the cobalt mineralization at the Altai is as yet unclear, owing to the following circumstances:

1) The cobalt minerals are very fine-grained and have the form of fine phenocrysts in the altered schists; 2) in the area under investigation a clear exposure has been encountered chiefly in steep canyon-like valleys whose borders are subjected at present to intensive erosion. Objects are, therefore, hardly accessible to research work. Finally, eritrin whosè development permits of distinguishing macroscopically the cobaltized rocks is unstable under conditions of weathering and intensive erosion.

On the other hand, mineralization of the fine impregnation type discovered in schists promises to be more regular. From this it will be clear that a further study of the cobalt-nickel mineralization of Mountainous Altai would be highly desirable considering the peculiarity of its manifestations.

Showings of a tungsten-molybdenum mineralization have been encountered as yet only in rocks of the scarn zone of the Atuurgol intrusion of porphyry-like granites. Ore minerals: molybdenite, scheelite, chalcopyrite, pyrrhotine, arsenopyrite and very rarely gold. Non-metallics: garnet, epidote, scapolite, diopside-gedenbergite, vesuvianite, occasionally orthite, calcite, etc. The mineralization is fine-grained, chemical analysis showed Mo-content 0.07% and W—0.03%. Showings of a Mo—W mineralization in the contact rocks of the Upper Paleozoic porphyry-like granites are of interest for the present just with regard to the presence of rare and disseminated metal-bearing intrusions at Mountainous Altai.

Showings of a tantalum mineralization have been encountered in segmatite granite veins related to the same porphyry-like granites. The ore-mineral columbite has been discovered in heavy fractions of crushed pegmatite granite specimens. Associated non-metallic minerals are tourmaline, black lithium mica and fluorite.

From the above considerations it follows that granite intrusions showing rare metal mineralization are developed over the area of Mountainous Altai under definite conditions of geological structure.

Future investigators are called to solve the problem whether these intrusions have created commercial concentrations of the above-mentioned metals and if not, which is the cause of their dissemination. With regard to Co and Ni an intensive search for primary deposits is necessary. As to the Nb and Ta group, it is more probable to encounter enriched concentrates in ancient alluvial deposits where heavy products of the erosion of apical portions of intrusive bodies have been accumulated.

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GENETICS

AGE DIFFERENCES IN SPONTANEOUS MUTATION IN MALES OF *DROSOPHILA MELANOGASTER* OF DIFFERENT ORIGIN

By A. I. ZUITIN and M. T. PAVLOVETZ

(Communicated by A. A. Richter, Member of the Academy, 5.VIII.1938)

There exists only one single investigation on the influence of the age of the sex-cells upon the frequency of mutation; it was conducted without application of X-rays and gives comparative information on the proportion of spontaneous lethal mutations arising in fresh sperms used for fertilization immediately upon hatching of males and the proportion of the identical mutations arising in older sperms applied 20 days following hatching of the males which were kept separately from females ([5]). The proportion of mutants in older sperms appeared to be higher than in young ones; the difference was, however, statistically insufficiently significant. Nevertheless Timoféeff-Ressovsky believes, on the basis of the results obtained ([6]), that mutation rate (Mutationsrate) should be calculated as proportion of mutations per absolute unit of time, and not per generation as generally done: he puts forward the statement that the probability of mutation is proportional to time while the existence of the genes themselves is not limited by any term. The work mentioned does not touch upon the question which is directly connected with the above conclusions, viz., whether or not the proportion of mutation does change in sperms of equal maturity and freshness at different moments of the male's life. In other words, does not the age of the soma influence the rate of mutation of sperms contained in it independently of the age of the sperms themselves?

In the present communication we have made an attempt to answer this question: proportions of sex-linked lethal mutations in sperms were determined: 1) during 1—5 days upon hatching of the male and 2) 25 days upon hatching. During the 20 days between the 1st and 2nd applications of the males they were kept with repeatedly renewed females; this guaranteed equally fresh sperm from the 25 days old males and from 1—5 days old ones.

As some investigators have proved that *Drosophila* lines of different geographic origin show different mutability [Muller ([3]), Dubovsky ([2]) and especially Demerec ([1])] which, as shown by Demerec, may be caused by genetic difference in a single gene, we have used for the above purpose normal lines which differed in their origin.

The more significant material was obtained from three of them, viz., «Sukhumi», «Ordjonokidze» and the laboratory line («112»). The former two were taken shortly before from nature and were kept in the laboratory only during four generations preceding experiment; the line «112» represents a branch of a normal line of foreign origin (from America) and was inbred during many years under uniform laboratory conditions.

As the summarized data of the table show, the two «natural» lines behave differently from the «laboratory» one. The two former are first of all distinguished by higher mutability: the total proportion of mutations in sperms of young males of the two Caucasian lines (1.309%) materially differs from that in the laboratory line (0.540%). Owing to lack of age differences in the latter, the data on the two ages may be joined for the purpose of comparison, and $t = \frac{\text{Diff}}{E_{\text{m diff}}} = 3.39$.

The principal and the most interesting difference between the two natural lines, on the one hand, and the laboratory line, on the other, consists in the significant decrease of the per cent of mutations with the age in the former, while no change in mutation frequency is observed in the laboratory line.

Summarized Data on the Analysis of the Mutational Variation in Sperms of Equal Age which Matured in Males Differing in Age and Belonging to Three Normal Lines of *Drosophila melanogaster* of Different Origin

Name of the line	Analysis of the sperms beginning with the 1—5 days upon hatching of the male			Analysis of the sperms beginning with the 25—30 days upon hatching of the male			Significance of the age difference in mutability $t = \frac{\text{Diff}}{E_{\text{m diff}}}$
	Number of sperms analyzed	Number of lethal mutations in the X-chromosome	% of mutations	Number of sperms analyzed	Number of lethal mutations in the X-chromosome	% of mutations	
«Sukhumi» . . .	880	8	0.909	717	3	0.411	$t = \frac{0.498}{0.282} = 1.77$
«Ordjonikidze» .	977	15	1.535	1346	4	0.297	$t = \frac{1.238}{0.256} = 4.83$
The two natural lines summarized	1757	23	1.309	2063	7	0.339	$t = \frac{0.970}{0.195} = 4.95$
The laboratory line	708	4	0.565	959	5	0.521	Insignificant

The drop of the mutation per cent with the age of males (and, consequently, of testes) is especially expressed in the line from «Ordjonikidze» which gives a statistically significant difference between the mutation frequency in sperms of young males and the frequency of mutation in sperms of equal age, but taken from old males (t=4.83).

In the line «Sukhumi» there is a less clear drop of variation with the age of the male; the difference of the same kind is, however, suggested clearly enough, so as to make it probable that the result should become statistically significant when more abundant material is subjected to analysis. Summation of the data on the two «natural» normal lines gives an equally significant difference between the age groups as that in the line «Ordjonikidze» taken by itself. In the laboratory line, on the other hand, there is practically no difference between the mutation rates in sperms taken from males of different ages (0.565 and 0.521%). The data presented above lead to the following conclusions and considerations.

We can see, first, that the age of males is far from being indifferent for the determination of mutability of a given line by the per cent of mutations in sperms, irrespective, moreover, of whether the males were kept without females (data by Timoféeff-Ressovsky) or together with females (our data for the two Caucasian lines).

We see, further, that in the lines of *Drosophila* which were recently brought to the laboratory, a relation between the frequency of mutation in equally fresh sperms, but taken from males of different age, is observed which differs from that in a line which was long inbred under laboratory conditions, the latter being equally uniform for all stages of development both of the soma and of the gametes. Does this difference represent an index of a different age adaptation in the natural lines as compared with the laboratory one, or a mere result of accidental selection of the three different lines possessing genotypically fixed peculiarities in variation of mutability with the age, or, finally, they are connected with differences of the character of gametic selection—will be shown by future investigations. Differences in the degree of homozygoty between the Caucasian lines and the laboratory one should not have influenced the results, as the sex-linked lethals were analyzed in the same males at different periods of their life. Differences in the mode of action of the gametic selection in case of sperms of identical age under identical conditions are scarcely probable.

Passing to the bearing of our data upon the idea of the direct proportionality of mutation to the factor of time, as put forward by Timoféeff-Ressovsky and supported by Stubbe ([4]), it should be noted that it may be considered correct only in the most general, schematic form in so far as all the natural processes require time. In our analysis the two series of sperms in Caucasian lines—from the young and from the old males—are of equal gametic age, but give nevertheless different percentages of mutations in spite of the genotypic identity of the sperms of the two series within each line and the similarity of the laboratory conditions. No proportionality between the mutation rate and the absolute time is, consequently, observed here.

The matter is, probably, not so much in the amount of time elapsed at this or that moment of the sperm's life, as in the kind of influence of the surrounding medium, to which the sperms were subjected during this or that period of time. Equality of microconditions at different ontogenetic stages signifies by no means equality of degree and character of interaction between different organic stages and these conditions, and, consequently, does not mean that mutational interaction of the sperms is equal at different moments of development of the individual.

It is possible that different geographic strains of *Drosophila*, in connexion with different ecological conditions in their natural habitat, display different genotypically determined co-ordination in the adaptation of the larval and adult life to external conditions which is fixed by selection. At any rate we can clearly see in the case of the line from «Ordjonikidze» that in the same males the proportion of mutations is significantly different in sperms of equal age but differently developed—under the conditions of larval and pupal life of the individual, or under the conditions of life of the adult organism. Further investigations will show to what extent these relations are spread and stable.

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GENETICS

THE INFLUENCE OF THE CHANGE OF THE THERMAL REGIME UPON THE FREQUENCY OF OCCURRENCE OF LETHAL MUTATIONS IN *DROSOPHILA MELANOGASTER*

By A. I. ZUITIN

(Communicated by A. A. Richter, Member of the Academy, 5.VIII.1938)

It was shown in the preceding communication(2) that the bilateral (complete) temperature contrasts are able of producing a more significant mutational variation than those simple temperature shocks (half-contrasts) which were used by many investigators, beginning with Muller(1).

Here are briefly communicated the results of experiments on the influence upon the mutational variation of the replacement of the stable (laboratory) thermal regime (25±1°C) by the fluctuating (natural) thermal regime with a simultaneous drop of the mean temperature.

Interesting results were already obtained in the first (preliminary) experiment in which flies of the *apricot* line served as a material; they were used in the preceding investigation (on the action of the temperature contrasts). Experimental cultures containing eggs were exposed to out of doors conditions and placed in the shade; systematic measurements of the temperature were made, and minimums and maximums were especially recorded every 24 hours. The control lines developed in the laboratory at a temperature of 25±1°C. In this experiment the temperature out of doors in the vicinity of the experimental cultures varied from 13 to 20°C, while the amplitude of the individual 24-hour fluctuations varied from 9 to 17°. The development lasted out of doors almost twice as long as in the control series: from 15 to 23 days in the experimental cultures and from 9 to 11 days in the control ones. Considerably less flies were hatching in the experimental cultures as compared with the control ones, and some of the males in the former proved to be sterile which was not the case in the latter. As the data presented in the general table show, among 419 analyzed sperms of the experimental males 3, or 0.716%, proved to possess a sex-linked lethal mutation, while in the control among 4601 sperms only 4, i. e. 0.087%, proved to contain lethals in the *X*-chromosome. The comparison of the experiment with the control gives $t = \frac{\text{Diff}}{E_{\text{m diff}}} = \frac{0.629}{0.128} = 4.9$, i. e., the difference between the proportions of mutations in the experiment and control exceeds its probable error almost 5 times. This means that the increased (8 times greater than in the control) mutational variation obtained in the *apricot*

line as a result of the change from the stable thermal regime to a fluctuating one possesses a significance which is sufficient for inducing one to attempt experiments on a larger scale.

In the following basic experiment a normal line of *Drosophila melanogaster* served as a material for the analysis of the action of the change of thermal regime upon the frequency of occurrence of lethal mutations; this line represents a branch of the normal line of American origin which was cultivated during many years at the laboratory of Genetics of the Academy of Sciences and later in our institution.

In the new experiment the temperature was fluctuating from +5 to +26°C (28.VI—23.VII 1937), and the amplitude of the 24-hours fluctuations varied from 5.5 to 12.5 degrees. The control flies were developing at a temperature of 25±1°C. Hatching of the experimental flies took place on the 19—26 day, that of the control ones within 8—11 days.

Like in the first experiment, part of the males proved to be completely sterile in the new experiment also, a certain part of males proved to possess, moreover, lower fertility. No drop of fertility was observed among the control males.

Summarized Data of the Experiments on the Influence of the Change of Thermal Regime (from Constant to Fluctuating) upon the Frequency of Lethal Mutations in the *X*-Chromosome of the Males from a Normal Line of *Drosophila melanogaster*

Line	Experiment and control	Number of sperms analyzed	Number of lethal and semilethal mutations	% of mutations	One mutation per	Comparison of the experiment with the control $t = \frac{\text{Diff}}{E_{\text{Diff}}}$
Apricot	Experiment I	419	3	0.716	140 gamets	$t = \frac{0.629}{0.128} = 4.9$
	Control I . .	4601	4	0.087	1150 »	—
Normal	Experiment II	4052	20	0.500	203 »	$t = \frac{0.327}{0.108} = 3.03$
	Control II . .	2306	4	0.173	576 »	—

The normal line proved to be twice as mutable as the *apricot* line, as may be seen from the comparison of the controls of the one and the other line (see table), namely, 0.087 and 0.173%. This made it still more evident that a considerable increase of the amount of material as compared with first preliminary experiment was desirable.

As may be seen from the table, among 4052 sperms 20 sex-linked lethal mutations, or 0.5%, were discovered in the second experiment, while only 4 lethal mutations, or 0.173%, were found among 2306 sperms. The difference amounts to 0.327% and is of high statistical significance, as $t = 3.03$.

Thus, independently of the differences in mutability between the experimental lines of *Drosophila* (*apricot* and normal) the results of the study of the influence of change of thermal regime on the mutational variation

are similar in principle. This coincidence of the results makes the statistical significance of the figures still greater.

It should be thus concluded that not only sharp-sublethal temperature contrasts are able of producing mutational variations, but a less pronounced change of thermal conditions leads also to a similar result, provided the whole character of the thermal regime is changed as, for example, in the experiments described above where a stable regime is replaced by a fluctuating one.

The significance of this conclusion for the explanation of the natural mutational variation will be treated elsewhere.

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GENETICS

THE COMBINED EFFECT OF CHANGE OF THE THERMAL REGIME AND THE SUBSEQUENT TEMPERATURE CONTRAST UPON THE FREQUENCY OF LETHAL MUTATIONS IN *DROSOPHILA MELANOGASTER*

By A. I. ZUITIN

(Communicated by A. A. Richter, Member of the Academy, 5.VIII.1938)

In the two preceding short communications I have presented the results of experiments on the relation between the degree of action of the unilateral and bilateral temperature contrasts upon the mutational variation in *Drosophila*(1), and the experimental results of the effect of the change of the thermal regime upon the mutational variation in the same object(2).

The results of the experiments of the combined effect of the two factors mentioned, the change of the thermal regime and the unilateral temperature contrast, are briefly outlined in the present paper.

Summarized Data of the Experiments on the Combined Action of the Change of Thermal Regime with Subsequent Temperature Half-Contrast upon the Frequency of Lethal Mutations in the *X*-Chromosome of Sperms in Males from a Normal Line of *Drosophila melanogaster*

Kind of the influence	The period when the influence took place	The age of the male at the moment of the analysis of sperms	Number of sperms analyzed	Number of lethal and semi-lethal mutations	% of mutations	The significance of the difference $t = \frac{\text{Diff}}{E_{\text{mdiff}}}$
Change of thermal regime	From the egg to the hatching of the fly (19—26 days)	1)1—6 days.	2514	16	0.636	2.5
		2)7—12 days	1538	4	0.260	5.3
Change of thermal regime and temperature leap up to 38°C	Adult males in the period from 14 to 20 days. 20 days old males during 2 hours	3)20—26 days	589	13	2.207	6.7
						8.5
						3.7
Control	—	1—6 days	2306	4	0.173	

The experiment was conducted on a normal line of foreign origin which was inbred during many years in our laboratory. The change of the thermal regime was attained by transferring flies at a definitive developmental stage to an out of doors shaded place where natural temperature fluctuations were operative. The control series were developing under ordinary laboratory conditions at a temperature $25 \pm 1°C$.

As it is shown in the two first columns of the table, the alternation of the influence upon the same series of flies occurred in the following way. At first series of eggs, laid under laboratory conditions in vials containing ordinary nutritive medium, were exposed to oscillating temperature out of doors where temperature fluctuations occurring within 24 hours were recorded. After hatching the males were transferred to laboratory conditions and in two six-day terms following one another were subjected by means of crossing with virgin flies *ClB* to analysis in order to determine the occurrence in their sperms of sex-linked lethals and strong semilethals (with a check in F_3). The surviving 14 days old males were after 2 days again transferred (together with females) for 6 days to fluctuating (natural) thermal regime. In this case, immediately following the 6 day long stay under the above-mentioned conditions, they were exposed for a short time (about 2 hours) to direct insolation which raised the temperature up to 38°C. As the flies were contained in vials made of ordinary glass stopped with cotton, the influence of ultra-violet rays was eliminated. Together with the temperature the humidity was also changed; its importance for the mutational variation will be the object of a special analysis; it was not especially considered here.

As a result of the combined action of the change of thermal regime followed by a temperature shock, the percentage of dying flies exceeded 62 and a considerable part of the surviving ones was completely sterile or not fully fertile. Nearly one third of the surviving fertile males, however, proved, upon analysis of their sperms, to possess sex-linked lethal or semilethal mutations.

Turning to the figures of the table, we see that the combined action of the change of the thermal regime with the temperature shock produced altogether 2.20% of lethal mutations in the *X*-chromosome of the sperms, while the action of a single change of the thermal regime, in spite of its length, gave only 0.636% of such mutations; it should be added also that in the latter case mutations could be recorded under more favourable conditions, i. e. within the first 6 days upon hatching of the males.

Comparison of the two effects reveals a difference amounting to 1.571% of mutations; it exceeds 5.3 times its probable error.

This result cannot be explained, even partly, by the age difference among the experimental males, since mature sperms themselves should have been of equal age in the two cases, owing to the fact that males were all the time kept in contact with females. The influence of the age of the organism of the males upon mutation frequency gives rather a decrease of the proportion of mutations than an increase; this was shown by a special investigation conducted by me in co-operation with Pavlovetz[3].

The result obtained can neither be explained by summation of the after-effect of the action of the first change of the thermal regime with the action of the second experimental change, since the analysis of the sperms of males of the second series after the first treatment, i. e. from 7 to 12 days following hatching of males, gave a definitive, although statistically insignificant, decrease of the per cent of mutations from 0.636 to 0.26 (see the table); it should have become stronger in the remaining 2 days (12—14), which passed before males were subjected to the second, combined treatment. Still

less adequate would be an explanation of the effect obtained by the sole semi-contrast influence which lasted merely for two hours. When we compare the percentage of mutations from the combined treatment (2.207%) with that during the preceding 7—12 days (0.260%), we find an increase of mutational variation more than eight times, a kind of a mutational leap. The corresponding difference exceeds its probable error 6.7 times and is, therefore, of high statistical significance.

When one compares the effect obtained from the combined action with the control series (per cent of mutation 0.173), increase of mutational variation a more than 12-fold becomes apparent, and the difference between the proportions of mutations in the two cases exceeds its probable error even 8.5 times, the statistical significance being beyond any doubts.

We see, therefore, that, while the temperature contrast and change of thermal regime taken separately are able to alter materially the mutation frequency as compared with that observed in the control laboratory material, the combination of the two influences proves to be an especially effective external factor of mutational variation.

As we undoubtedly meet in nature temperature fluctuations of the kind described above, the conclusion on the significance of the present data for the explanation of the natural mutational variation suggests itself. While a more detailed treatment of this problem will be made later, we shall only emphasize here the idea which was put forward in our first work on this subject(1): the explanation of the natural mutational variation, in as much as it depends on external conditions, should be sought for in extraordinary changes of the common factors of the medium, in the first line thermal ones, which surround the developing organic form.

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GENETICS

NEW TETRAPLOID BARLEYS—THE HULLED AND THE NAKED

By G. D. KARPECHENKO

(Communicated by N. I. Vavilov, Member of the Academy, 9.VIII.1938)

The first description of tetraploid barleys, given by the writer in an earlier article (1), concerned tetraploids in two varieties, Viner 01163 and Europeum 0353/135. Doubling of the chromosome set was induced in that case by high temperature treatment applied during the first divisions of the zygote. Further experiments with other varieties also proved successful, so that the author now disposes of tetraploid plants both of the hulled, two-rowed barley, Colchicum 10/30, and of a new, naked, two-rowed variety, brought up by the All-Union Institute of Plant Industry, and assigned the name «Kolkhoz».

The procedure of temperature treatment somewhat differed from that resorted to in earlier experiments. The plants were grown in pots and after castration and pollination placed in a chamber with a constant temperature kept at 25°C, whence after 24 hours they were transferred to a chamber with a temperature of 50°C, to be kept there for 30, 45 or 60 minutes respectively. The plants were kept in the 25°C-chamber longer than it was the case in the preceding experiment, this being necessitated by their lower rate of development due to the advanced season (the experiments were done in September). In Table 1 data are summarized from experiments with both varieties.

Table 1

Results of Experiments on the Effect of High Temperature Treatment During the First Divisions of the Zygote in Barley

Variety	Kolkhoz			Colchicum 10/30	
Temperature	+ 50°C			+ 50°C	
Duration of treatment	30′	45′	60′	30′	45′
Flowers treated	48	244	88	98	81
Seeds set	12	102	38	16	0
Plants grown	8	95	32	14	0
Tetraploids obtained	0	1	0	1	0

As may be seen from the above table, one tetraploid plant of each variety was obtained. These were singled out among other plants by their morphological peculiarities; being afterwards subjected to cytological investigation, they proved to possess a double chromosome number (Fig. 1). In the case of the tetraploid Kolkhoz, out of the six root-tips investigated, two proved tetraploid and four diploid, while all the stems were tetraploid, which was established by a determination of the chromosome number in

a *b*

Fig. 1. Somatic chromosome plates of tetraploid barley: *a*—of the variety Kolkhoz; *b*—of the variety Colchicum. ×2400.

the progeny. At the beginning of its development this plant was, consequently, a chimera. In the case of the Colchicum tetraploid three root-tips were investigated, all of which proved tetraploid; an examination of the seeds showed the stems to be tetraploid too.

Both diploid and tetraploid plants were grown in pots in a greenhouse. With respect to the vegetative period, the tetraploids scarcely differed from

Table 2

Comparative Data on Tetraploid and Diploid Barleys

Characters	Kolkhoz			Colchicum 10/30		
	Tetraploid	Diploid		Tetraploid	Diploid	
		$M \pm m$	n		$M \pm m$	n
Height of plant (in cm)	125.2	127.8±1.7	20	118.5	123.3±1.4	13
Thickness of straw at top (in mm)	2.5	1.8±0.1	20	2.3	1.9±0.04	13
Thickness of straw at bottom (in mm)	4.5	3.7±0.1	20	4.0	3.4±0.1	13
Length of spike rachis (in cm)	10.3	9.1±0.2	20	11.8	10.0±0.3	13
Number of flowers per spike	31	32.7±0.5	20	30	32.6±0.8	13
Number of grains per spike	21	30.5±0.5	20	20	30.4±0.8	13
Average length of grain (in mm) (20 grains measured)	10.5±0.2	8.0±0.1	20	11.2±0.1	9.4±0.2	20
Average width of grain (in mm) (20 grains measured)	4.0±0.1	3.9±0.1	20	3.7±0.04	3.6±0.03	20
Weight of 20 grains (in g)	1.43	1.14	—	0.985	0.94	—

the diploids, except that they usually grew mature one or two days later. As regards height, they proved slightly shorter than the diploids. In Table 2 are summarized data obtained from a comparative study of the new tetraploids and their initial forms, as regards straw, spike and grain characters.

From this table, as well as from Fig. 2 and 3, it may be clearly seen that the changes induced by doubling the chromosome set in the varieties Kolkhoz and Colchicum are of the same nature as those reported in the case

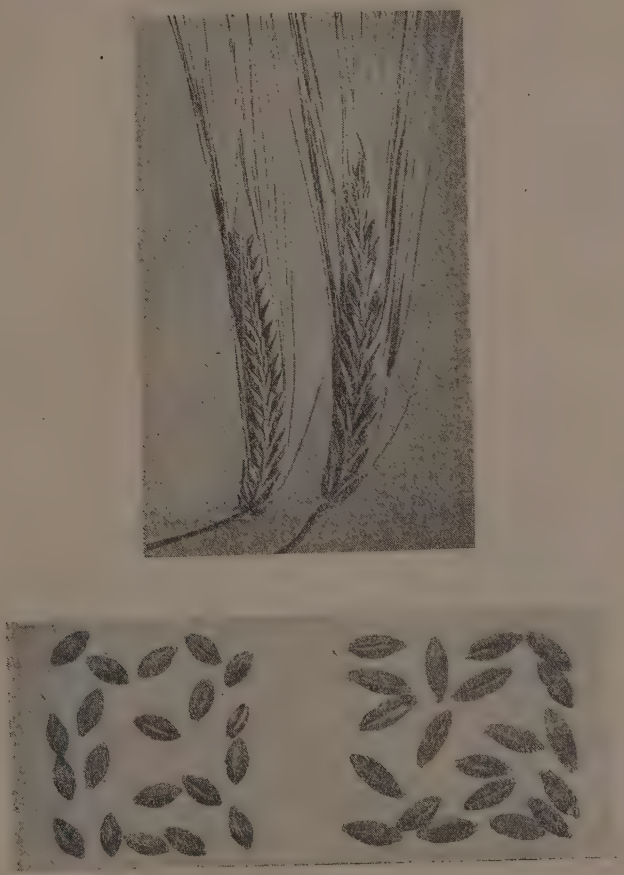

Fig. 2. Kolkhoz barley—spike and grains: left—diploid; right—tetraploid.

of the varieties Viner and Europeum, namely, thickening of the straw, lengthening of the spike rachis, decrease of the number of flowers and particularly in the number of grains per spike, as well as increase in the size and weight of the grain. However, the changes induced in different varieties differ quantitatively. Thus, as may be seen from Table 2 and the figures, the grain in the Kolkhoz tetraploid is greatly enlarged, while in the Colchicum tetraploid it is but slightly augmented. This greater increase in size is not connected with nakedness, as one might easily suppose, since the tetraploids of the hulled variety Viner also showed considerably enlarged grains (1).

Now that tetraploids of different varieties of barley are available, they can be crossed with each other and with diploids for the purpose of comparative study of heredity in tetraploids, diploids and triploids. It seems

Fig. 3. Colchicum 10/30 barley—spike and grains: left—diploid; right—tetraploid.

probable that hybridization of tetraploids inter se, accompanied by appropriated selection, will result in an increased fertility of the tetraploids, which is a matter of practical importance. Moreover, utilization of tetraploid barleys in distant hybridization seems to promising too.

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GENETICS

BLOOD VALUE OF CROSS-BREEDS BETWEEN THE WILD *OVIS POLII KARELINI* SEW. AND THE DOMESTIC SHEEP

By V. I. PATRUSHEV

(Communicated by N. I. Vavilov, Member of the Academy, 27.VII.1938)

When producing new breeds of farm animals by means of wide hybridization, a proper selection of the most virile and productive animals is of particular importance. So far only the usual zootechnical methods have been employed in this kind of work. In connection with the problem of producing a new breed of mountainous fine wool sheep by crossing the ram of the wild *Ovis Polii Karelini* Sew. with the Merino, the Institute of Genetics of the Academy of Sciences of the USSR, when making a selection of the best hybrids, set itself the task of utilizing the methods of physiology, biochemistry and other biological sciences in addition to the usual zootechnical methods.

It was our object to study the correlation of the blood value of the different breeds utilized in crossing with their productivity. The work was done in October 1937 at the base of the Institute of Genetics on the Iliych Pedigree Farm in Kirghizia. We investigated 345 sheep including 250 cross-breeds between the wild *Ovis Polii Karelini* Sew. and the New-Caucasian Merino, Precoce and Kurdyuk (F_1 and F_b). The blood was examined for dry residue, specific gravity, resistance of erythrocytes, concentration of total and reduced glutathione, catalase activity (V. I. Patrushev) and also for number and size of erythrocytes, haemoglobin value and alkalinity reserve (Kushner). The animals grazed in the mountains and throughout the night before the examination were denied both food and water. Blood for analysis was taken from the jugular vein in the morning hours.

Let us subject to analysis the results of our investigation separately for each index.

Glutathione Concentration of the Blood. The glutathione concentration of the blood of sheep and other animals is liable to age variation. The ewes of the Precoce may serve as an example. In the first year the glutathione value of their blood shows a sharp rise from 16/20 to 30/33 mg% (the numerator indicating reduced glutathione and the denominator total glutathione). In the following years until the attainment of maturity the glutathione concentration remains relatively uniform. Sexual dimorphism has also been observed. Even male lambs in comparison with female lambs show a higher glutathione value. Thus, for example, the Precoce lambs born in 1937 showed a glutathione value of 15.8/20 mg% for the female

lambs against 20.1/24.3 mg% for the males. A similar picture is presented by hybrids from a cross between the wild *Ovis Polii Karelini* Sew. and the Merino, by back-crosses with the latter, by F_b Precoce hybrids and others.

Differences in total glutathione concentration of the blood of various breeds are not great in adult sheep. Female Precoce and local female Merinos show the highest content of total glutathione for females above 18 months of age (33.6—38.3 mg%); the Kirghiz Kurdyuk sheep show a somewhat lower content of total glutathione (30.3 mg%).

Precoces also take the lead in reduced glutathione concentration showing 30—30.8 mg%; they are followed by Merinos with 27.8 mg% and Kurdyuks with 27.3 mg%. The probability of difference (P%) as between the Precoce and the Kurdyuk is 96—99%. The different breeds show a different content of oxidized glutathione. Taking the total glutathione value to be 100, the oxidized glutathione will equal about 11% for the Precoce, about 18% for the Merino and about 9% for the Kurdyuk. A comparison between New-Caucasian and Precoce adult rams shows that the former is somewhat behind in regard to the content of total and reduced glutathione. Adult hybrids (females) of the first generation show a higher concentration of total and reduced glutathione as compared with the domestic parents. The cross between the Kirghiz sheep and the wild *Ovis Polii Karelini* Sew., compared with its domestic parent, shows 26% greater content of reduced glutathione and 29% greater content of total glutathione (P=95—100%). The glutathione concentration of the cross between the wild *Ovis Polii Karelini* Sew. and the Merino is higher than that of the Merino by 22% (P=94—95%) in regard to reduced glutathione and by 7% in regard to total glutathione. Cross-breeds between the wild *Ovis Polii Karelini* Sew. and the Kirghiz sheep, both male and female, show a somewhat higher content of glutathione than cross-breeds between the wild *Ovis Polii Karelini* Sew. and New-Caucasian dams. Adult hybrids F_b, male and female, the progeny of a cross between males F_1 and females of the original domestic breed, have in every instance shown a glutathione value below that of their male parent F_1 and equalling that of the original domestic breed. Hybrid lambs of the age of six months show a higher glutathione value than pure blood lambs of the same age. Thus, for instance, the total glutathione content of only-one-yearling rams is by 25% higher than that of Precoce-Merino rams of the same age (P=91—97%). Yearling ewes present a similar picture.

Activity of Catalase. The catalase activity of the blood of sheep (Precoce) gradually declines after the animal attained its eighteenth month. Rams show a higher catalase activity than ewes.

The catalase activity of adult Precoce dams in no way differs from that of the Kurdyuk (4.5—4.7). Only a slight difference is to be observed between Precoce and Merino rams (5—4.5). The catalase activity of Precoce ewes at the age of 18 months considerably exceeds that of the Merino (5.3—3.4) (P=100%). The catalase activity of the first generation of cross-breeds between the wild *Ovis Polii Karelini* Sew. and the Kurdyuk does not differ from that of the Kurdyuk (4.85—4.7).

The catalase activity of cross-breeds F_1 (wild *Ovis Polii Karelini* Sew. × × Merino) is much higher (4.75) than that of the Merino (3.4) (P=98.8%).

The catalase activity of the blood of the cross-breed between the wild *Ovis Polii Karelini* Sew. and the Kurdyuk is somewhat higher than that of the cross-breed between the wild *Ovis Polii Karelini* Sew. and the Merino (5.4—4.3). Assuming the inheritance of catalase activity to approximate the intermediate type, it may be presumed that the catalase activity of the wild *Ovis Polii Karelini* Sew. is somewhat higher than that of the Kurdyuk.

Cross-breeds of the second generation from a cross between rams F_1 (wild *Ovis Polii Karelini* Sew. × Merino) and Precoce dams show a lower catalase activity as compared with that of Precoce sheep of the same age (4.9—5.3) and a higher one as compared with the Merino (4.9—3.4) and F_1.

Very interesting from the point of view of the study of the inheritance of catalase activity is the clearly defined bicolumnar aspect of the curve showing the distribution of the sheep of the second generation.

Dry Substance of the Blood. The dry residue of the blood continues to increase until the animal attains the age of eighteen months and then, beginning with the age of two years and a half, a slight decline sets in. The sex differences are clearly evident in all age groups, the males showing a higher blood value. Differences connected with hybridization run concurrently with most of the other blood factors.

Compared with the domestic breeds used in crossing, such as the Merino and the Kurdyuk, the cross-breeds of the first generation, both male and female, show a higher content of the dry susbtance of the blood (P=97.9—99.7%).

In the case of hybrids from a back-cross with the original domestic breed, the dry substance of the blood shows a diminution compared with that of the hybrid of the first generation. Compared with triple cross-breeds (wild *Ovis Polii Karelini* Sew. × Merino × Precoce), cross-breeds of the Kirghiz sheep show a higher percentage of dry residue in the blood.

The former group, in its turn, shows a higher percentage of the dry substance in the blood than the hybrids from a back-cross with the Merino. The parent breeds of sheep show slight differences and are placed in the following receding order: Kurdyuk, Precoce, Merino.

Specific Gravity of the Blood. The specific gravity of the blood like any of the other blood values increases until the animal had attained eighteen months, after which it remains relatively uniform. There is a certain difference in regard to the specific gravity of the blood between twin-yearlings and only-ones, revealed at the age of six months. Thus, for instance, the specific gravity of the blood in young ram twins Precoce-Merino is 1.0484 and in the only-ones 1.0586. A similar correlation is to be observed in the F_1 Precoce and the F_b Merino. Thus, the only-ones compared with twins show a higher specific gravity of the blood. Differences connected with hybridization are sufficiently clearly expressed.

All cross-breeds of the first generation, compared with the domestic parents, show a higher specific gravity of the blood. The specific gravity of the blood of the Merino ram is 1.0575 and that of the hybrids between the Merino and the wild *Ovis Polii Karelini* Sew. is 1.0646. The hybrid dams of a similar cross, compared with the Merino sheep, show a higher specific gravity of the blood.

The cross-breed between the wild *Ovis Polii Karelini* Sew. and the Kurdyuk shows a higher specific gravity of the blood as compared with that of the domestic parent and that of the F_1 cross between the wild *Ovis Polii Karelini* Sew. and the Merino (P=94%).

Thus, there is reason to believe that the specific gravity of the blood of the wild *Ovis Polii Karelini* Sew. is considerably higher than that of the domestic sheep. In cross-breeds from a back-cross with the Kurdyuk or the Merino the specific gravity of the blood as compared with cross-breeds of the first generation is reduced to that of the domestic sheep. It is noteworthy that cross-breeds from a cross between F_1 (wild *Ovis Polii Karelini* Sew. × × Merino) and the Precoce, compared with cross-breeds of the first generation and also with cross-breeds from a back-cross with the Merino and the Kur-

dyuk, show a further rise in the specific gravity of the blood of both young rams and ewes.

The original breeds of domestic sheep used in crossing show no clear distinctions in regard to the specific gravity of the blood. Among them only the Precoces are distinguished by somewhat higher values.

Resistance Power of Erythrocytes. Six-months-old female Precoces, compared with eighteen-months-old sheep, show a slightly greater resistance power of the erythrocytes, that is, the latter dissolve and precipitate in lower concentrations of saline. No age differences in the resistance power of the erythrocytes are to be observed after the animal had reached the age of six months.

The resistance power of erythrocytes in only-one yearlings is slightly greater than that of twins.

The resistance power of the erythrocytes of cross-breeds differs greatly from that of the parent stock of sheep. Cross-breeds of every description show a greater resistance of the erythrocytes both in rams and ewes (P=97—100%).

The second generation of cross-breeds (F_b) approximates the domestic breeds in regard to the resistance power of erythrocytes. Cross-breeds from a cross with Kurdyuk sheep constitute an exception showing a reduced resistance power. Compared with cross-breeds of the F_b Precoce type, six-months-old rams and ewes of the F_b Merino cross-breed show a reduced resistance power of the erythrocytes.

Among the domestic breeds used in crossing the Kurdyuk shows the highest resistance power of the erythrocytes.

Thus, taking the resistance power of the erythrocytes to be an indication of their age we find that the cross-breeds of the first generation are marked by the highest age of the erythrocytes; next comes the second generation followed by the Kurdyuk, Precoce and the Merino.

Conclusion. In regard to most of the blood factors the breeds of domestic sheep investigated by us present the following distribution: the Kurdyuk takes the lead and is followed by the Precoce which in its turn is followed by the Merino.

However, in regard to a number of factors the picture is different. Thus, the Kurdyuk is at the bottom of the list in the glutathione value of the blood. In different breeds the catalase activity is different only in young sheep. In regard to the specific gravity of the blood only the Precoce is somewhat advanced while the distinctions among the other breeds are not clear.

As to the mode of inheritance the blood factors have been placed in two unequal groups. The glutathione concentration, the dry residue, the specific gravity and the resistance of the erythrocytes have been placed in the first group and the catalase activity in the second. The F_1 hybrids leave their domestic parents behind in every factor of the first group. The second generation, the outcome of a back-cross, shows no segregation. The blood factors, compared with those of the first generation, decline to the level of the parents (in glutathione value) or to the level of the intermediate value between F_1 and the parents (in all the other factors of that group).

Thus, the type of inheritance approximates the intermediate polyfactorial type. It should be admitted that the blood value of the wild *Ovis Polii Karelini* Sew. is higher than that of the domestic sheep.

In catalase activity there is no difference between hybrids of the first generation and the domestic sheep, but in the second generation from a back-cross there is a clear segregation into two groups. Thus, the considerably simpler mode of inheritance of this character is evident.

The *Ovis Polii Karelini* Sew. is one of the biggest varieties of the wild rams (twice in body weight as the Merino); it is distinguished by its lepto-

some breathing type of constitution while the domestic sheep shows a tendency towards the opposite type of the digestive constitution. This is corroborated by the following comparative data: the length of the intestines of the Kirghiz sheep is greater than that of the wild *Ovis Polii Karelini* Sew.; on the other hand, the weight of the heart, lungs and kidneys of the latter is greater than that of the Kirghiz sheep.

The hybrids attain earlier maturity and like their domestic parents have a finer wool than the wild *Ovis Polii Karelini* Sew. and to a considerable degree retain the long legs, slenderness of body, spare and strong constitution, qualities which are essential in highland conditions.

Cross-breeds between the wild *Ovis Polii Karelini* Sew. and the Merino are at birth somewhat larger than the Merino and further on retain their advantageous position (of an intermediate value between the wild parent and the Merino).

Hybrids of the first generation from a cross between the wild *Ovis Polii Karelini* Sew. and the Kirghiz sheep are larger than the hybrids from a cross between the same wild parent and the Merino.

The hybrids from a cross between F_1 and the Merino which were investigated by us are, at the age of six months, somewhat behind the hybrids of the first generation. The triple hybrids F_1 (wild *Ovis Polii Karelini* Sew. $\times$ Merino $\times$ Precoce) show a more rapid growth and at the age of eighteen months are ahead of the hybrids of the first generation in body weight.

All this leads to the conclusion that the gradation of the breeds in accordance with blood value as given previously does not clash with the gradation of these groups in accordance with body weight and rate of growth.

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GENETICS

POLYPLOIDY IN THE HIGH MOUNTAIN REGIONS OF PAMIR AND ALTAI

By A. P. SOKOLOVSKAJA and O. S. STRELKOVA

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The attention of a number of investigators is at present attracted by the problem of adaptation of polyploids to extreme conditions of life. The works on this subject may be classed as follows: 1. Works stating the occurrence of polyploids in extreme climatic zones ([2],[3],[4],[7],[11]). 2. Works pointing out a correlation between certain edaphic factors (salinity and lime content) and the per cent of polyploid occurrence ([5],[9] and others). 3. Works cariologically investigating the flora of a certain region. These works either state the per cent of polyploids growing in the northern parts of the region in question as compared with the southern ([8]), or point out the great occurrence of polyploids under unfavourable habitat conditions ([6]).

All the literary data available show that the appearance of polyploidic species and races is possible under unfavourable conditions in respect of soil, temperature, etc. An investigation of the high mountain vegetation of Pamir (1936) and Altai (1937) has been made by the authors with the object of establishing a certain regularity in the distribution of polyploids.

The possibility of origination of polyploids in mountainous regions is great, particularly under the rigorous, cold conditions of a high mountain desert, such as Pamir. The latter is characterized by extremely wide temperature variations, night frosts and high day temperatures, short season of growth and great aridity of both air and soil due to the small amount of annual precipitation (about 60 mm). It would appear that the occurrence of polyploids might be expected in the alpine zone of the mountain regions of Altai too, whose climate, though milder than that of Pamir, is, however, continental, soil conditions being not always sufficiently favourable.

150 species in Pamir and 200 in Altai were cariologically investigated. Of those 85% and 65%, respectively, proved to be polyploids. However, the problem of geographical distribution of polyploids is not to be solved on the basis of percentage relations.

As a starting point in an inquiry into the origination of polyploids an analysis of the geographical distribution of species should be made, the ways of migration of the species determined, and the physico-geographical conditions under which the formation of a certain species proceeded should likewise be considered.

An investigation of the vegetation of these mountainous regions permitted of advancing a number of statements. A study of the Pamir material largely represented by species of the *Gramineae* revealed the following regularity:

Species (of different genera of grasses) in the high mountain regions usually appear to be polyploids as opposed to those having an area of distribution principally restricted to plain territories. As an example species of the genus *Poa* may serve, among which *Poa sibirica* Roshw. with 2 $n=28$ chromosomes ranges mostly over the meadow-lands of valley territories; *Poa alpina* L., *Poa altaica* Trin., *Poa tibetica* Munro and others have 2 $n=42$ chromosomes and are native of high mountain meadows. Species of the genus *Alopecurus*, as *A. pratensis* L., *A. geniculatus* L., and others distributed over plains, have 2 $n=28$ chromosomes; the species *A. vaginatus* Pall., *A. mucronatus* Hack., and others having 2 $n=56$ chromosomes are restricted to mountain ranges.

This statement has been fully confirmed by a cariological analysis of the grasses of Altai.

Representatives of twenty families other than grasses were examined in addition, as it appeared of interest to verify the above statement on other taxonomic groups. An examination of the material has shown that in mountain habitats diploid species occur along with species having high chromosome numbers.

As examples of species with high chromosome numbers different species of the family *Compositae* may be referred to, as *Senecio resedifolius* Less., *Senecio campester* Dc. having 2 $n=46$ chromosomes; *Ligularia altaica* Dc., 2 $n=48$ chromosomes; *Leontopodium campester* Beauv., 2 $n=49$ chromosomes; *Gnachalium silvaticum* L., 2 $n=58—60$ chromosomes; species of the genus *Aster—Aster flaccidus*, 2 $n=54$ and *Aster alpinus*, 2 $n=36$ chromosomes; species of the genus *Polygonum*: *P. polymorphum* Ledb., 2 $n=46$, *P. Bistorta* L., 2 $n=46$, and *P. viviparum* L., 2 $n=83—88$ chromosomes. The following form exceptions: *P. nodosum* Pers., *P. pamirium* Korsh., *P. hydropiper* L. These have 2 $n=22$ chromosomes.

This group with high chromosome numbers also comprises species of the genus *Saxifraga*, as *S. hirculus* L., *S. punctata* L. which are tetraploids with 2 $n=28$ chromosomes, *S. melaleuca* Fisch. with 2 $n=40$ and *S. hieracifolia* Waldst. with 2 $n=80—82$ chromosomes. Some species of the extensive family *Ranunculaceae* are also characterized by polyploid series.

Thus, species of the genus *Aconitum*, as *A. barbatum* Pers., *A. excelsum* Rchb. are diploids with 2 $n=16$ chromosomes. The area of distribution of the latter is restricted principally to wood and meadow-lands, while the tetraploid species as *A. Anthora* L., *A. altaicum* Steinb. with 2 $n=32$ chromosomes are confined to mountainous regions. The species of the genus *Ranunculus*, as *R. monophyllus* Ovcz. with 2 $n=32$ and *R. pulchellus* C. A. M. with 2 $n=40$ chromosomes are also distributed in mountainous localities.

The group characterized by low numbers of chromosomes comprises the following species:

The species of the genus *Gentiana*, as *G. altaica* Laxm., *G. septenfida* Pall., *G. algida* Pall. which are diploids with 2 $n=26$ chromosomes notwithstanding their confinement just to high mountain alpine meadows; species of the genus *Primula—P. algida* Adams, *P. longiscarpa* Ledb. with 2 $n=18$, *P. nivalis* Pall., *P. sibirica* Jacq. with 2 $n=22$ chromosomes.

Likewise the species *Dracocephalus imberbe* Bge. with 2 $n=10$ and *Dracocephalus altaiense* Laxm. with 2 $n=14$ chromosomes, the species of the genus *Phlomis*, as *Phlomis alpina* Pall. having 2 $n=24$, *Nepeda macrantha* with 2 $n=18$ chromosomes and species of the genus *Pedicularis* (of the fam. *Scrophulariaceae*), as *P. amoena* Adams, *P. proboscidea* Stev., *P. compacta* Steph., having 2 $n=16$ chromosomes—are all of low chromosome numbers.

This group comprises also the genera *Trollius* and *Aquilegia* of the family *Ranunculaceae*, which retain their chromosomal constancy and have 2 n=16 for the genus *Trollius* and 2 n=14 chromosomes for the genus *Aquilegia*, despite their distribution both over mountainous and arctic regions.

Such a study of the vegetation of Pamir and Altai has shown that the restriction to and migration along mountain ranges of species is not always concomitant with polyploidy. In this case it would appear that species originated at distant geological epochs simultaneously with the formation of mountain ranges, or even ere that, may retain their chromosomal sets, gradually adapting themselves to the shifting conditions of existence. The migration of these species along mountain ranges should be regarded not as a distribution over new, uncommon habitats, but as an extension of the area of their distribution under the same conditions as prevailed during the origination of a given genus. The genus *Gentiana* highly characteristic of the high mountainous alpine formations presents such an example. According to the data presented by Kusnetzov[10] the formation of the above genus had taken place before the rise of the Central Asiatic mountain range, the latter just being the centre of origin of the subgenus *Eugentiana* comprising the species under discussion. The genus *Primula* too may be regarded as originated in mountains [Brunn[1]]. It should also be taken into account that a number of species differ in their power of response to the effects of external conditions and that a particular species is more or less capable of adaptation.

The genera *Trollius* and *Aquilegia* may examplify the small variation of species displaying no readjustment in the nuclear system under extreme conditions of existence. The species of these genera remain constant in respect of their chromosomes all over the area of their distribution while the taxonomically related genus *Caltha* contains within the boundaries of *Caltha palustris* types with variously high chromosome numbers, 2 n=32, 48, 56.

The restriction to mountainous habitats of a group of polyploid species (of the fam. *Compositae*, *Gramineae*, *Saxifragaceae* etc.) may be explained by the fact that in the course of their migration species of these families got under extreme conditions of existence (as climate, soil, temperature etc.), different from those under which the formation of the genus went on. When subjected to the effects of these uncommon conditions species of this group, having at the same time a greater power of adaptation, sharply respond to these by a change in their chromosomal set. Naturally enough, a change in the nuclear system involves an alteration of the normal process of reduction division which leads to the formation of autopolyploids.

As shown by our investigations, we observe in some cases polyploids with greater numbers of chromosomes in the arctic zone than in the mountainous regions, e. g. *Alopecurus glaucus* having 2 n=130, *Agrostis borealis* with 2 n=56, *Elymus arenarius* with 2 n=56 chromosomes etc. This is to say that these species are extreme members of the polyploid series of this genus. *Saxifraga hieracifolium* extending as far as the arctic zone has 2 n=80—82, while *S. melaleuca* with an area of distribution confined to mountain ranges has 2 n=40 chromosomes.

Polyploidy (the term including both autopolyploidy and allopolyploidy) plays a great part in the process of evolution. Mountain ranges as well as the arctic zone (as shown by Flovik's investigations on grasses) are the fields of great processes of formation of species. Species in these regions reaching the margin of their area of distribution may sharply respond to extreme conditions of life by a change in their chromosome sets and give rise to new polyploid forms. The presence of a great number of polyploids in mountain habitats points to the fact that during the geographical distribution of spe-

cies and during their colonization of new territories polyploids will more readily than diploids adapt themselves to unfavourable climatic, temperature and other conditions of life.

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PLANT PHYSIOLOGY

DYNAMICS OF CARBOHYDRATE ACCUMULATION IN PLANT LEAVES AS INFLUENCED BY DIFFERENT CONTENT OF CO_2 IN AIR

By L. M. DOROKHOV

(Communicated by A. A. Richter, Member of the Academy, 5.VIII.1938)

Many investigators studied the question of how various concentrations of CO_2 in air influence photosynthesis and harvest; suffice it to quote the works of Godlewsky, Krausler and others ([1–8]), and our own experiments with vegetable crops ([9]). All the above authors came to the conclusion that photosynthesis in plants is considerably intensified with the increase of CO_2 concentration in air.

On the other hand, Chesnokov and Basyrina ([10, 11]) in their recently published articles refute the possibility of an intensified assimilation caused by CO_2. Data previously obtained are referred by these authors to errors due merely to the inadequate method these investigators resorted to in their works on photosynthesis. Chesnokov and Basyrina consider CO_2, in case of its high content in the air, as having a purely irritative or stimulative effect upon growth, which in their opinion should lead to increased harvest ([11]).

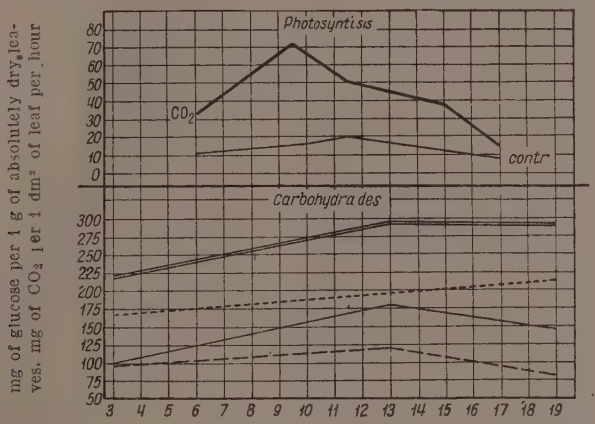
In the following work we aimed to investigate the dynamics of accumulation of carbohydrates in plants cultivated under various conditions as to CO_2 content in air. Quantitative analyses of products of photosynthesis made at definite intervals of time could give a full idea of the carbohydrate equilibrium in plants subjected to different CO_2 regime. At the same time these analyses would check the reliability of the data on photosynthesis obtained by the method of its determination in a constant air flow.

In a hothouse, in contiguous glass chambers of 18 m^3 each, there were grown 200 cucumber and 300 lettuce plants. In one of these rooms (the control one) the CO_2 content in air during the cultivation of plants and carbohydrate estimation did non exceed 0.06%, while in the other one the CO_2 content was kept as high as 0.90% by means of a gas bomb.

In July, by the time of appearance of the first blossoms in the cucumber plants and of formation of flower stems in lettuce, photosynthesis and respiration were determined, and at the same time samples for estimation of carbohydrate content were taken, which was done within 5 days.

The first sample of leaves was taken before photosynthesis set in (at 3—4 o'clock), the last one at 19 o'clock, while the intermediate tests were made at 7, 11, 13 and 16 o'clock respectively. The average test portion for carbohydrate content was made up of 30 leaves of cucumber plants and 100 leaves of lettuce, taken from different plants. From cucumber plants

there were taken the fourth leaves from the top on July 9, and the third ones on August 10. From lettuce plants for this purpose the third, fourth, fifth, sixth and seventh leaves were cut from 20 plants. To the analysis were subjected leaf blades (without petioles) which immediately after cutting from the plant were placed for 1 hour in exsiccators saturated with sulphuric ether vapours. After treatment with sulphuric ether vapours, the vegetable material was dried at a temperature of 50—60° C, reduced to powder in a porcelain mortar, sifted through a metal sieve and air dried at room temperature. On the day of estimating carbohydrates the per cent of hygroscopic water was determined in order to calculate the weight of the absolutely dry mate-



Photosynthesis and accumulation of carbohydrates as influenced by various content of CO_2 in air
Cucumber leaves on 9. VII

Soluble ——— at 0.06% CO_2 ------ at 0.90% CO_2
Total of carbohydrates ..... at 0.06% CO_2 ═══ at 0.90% CO_2

rial taken for the analysis. The values of CO_2 content are reduced to 1 g of absolutely dry leaves.

Analyses involved estimation both of total carbohydrate content and of the content of soluble carbohydrates. The difference between both contents gave the quantity of unsoluble carbohydrates. In order to extract soluble carbohydrates (mono- and disaccharides) the weighed portion was steeped in water at 40° C during an hour and a half. The hydrolysis of disaccharides (saccharose, maltose) was achieved in total water extract with 0.8% of HCl kept for 3 hours in a boiling water bath (100°). The proteins were precipitated with lead acetate. In estimating the total content of carbohydrates, the weighed portion of leaves was treated with 0.8% HCl and the retort placed for 3 hours in a boiling water bath for hydrolysis. In applying the above procedure of extraction, starch, dextrines and hemicellulosa were made to pass into the solution. The quantitative estimation of carbohydrates after their conversion into monosaccharides by hydrolysis was made according to Issekuts' ([12]) iodometrical method and expressed in mg of glucosa. The results of these analyses are given in Tables 1 and 2. From these tables it may be seen that the experimental plants differed considerably from the control ones both as to the total content of carbohydrates and as to that of soluble carbohydrates. The amount of soluble carbohydrates in control and experimental plants (gasified with CO_2) during morning hours (previous to photosynthesis) was about the same. The difference became

Table 1

Dynamics of Carbohydrate Accumulation in Cucumber Leaves as Influenced by Various CO_2 Content in Air (in mg of glucose reduced to 1 g of absolutely dry leaves)

Hour	9.VII						10.VII						27.VII					
	Soluble		Insoluble		Total		Soluble		Insoluble		Total		Soluble		Insoluble		Total	
	Control	CO_2	Control	CO_2	Control	CO_2	Control	CO_2	Control	CO_2	Control	CO_2	Control	CO_2	Control	CO_2	Control	CO_2
3	98.3	100.7	65.4	118.0	163.7	218.7	—	150.2	—	115.1	—	265.3	—	—	—	—	—	—
4	—	—	—	—	—	—	112.6	—	64.2	—	176.8	—	—	—	—	—	—	—
5	—	—	—	—	—	—	—	—	—	—	—	—	96.5	96.4	22.6	146.5	118.1	242.9
7	—	—	—	—	—	—	132.6	154.7	18.1	82.8	150.7	237.5	—	—	—	—	—	—
11	—	—	—	—	—	—	144.0	176.6	48.6	114.9	192.6	291.5	—	—	—	—	—	—
13	106.5	178.6	73.2	112.5	179.7	291.1	140.5	172.7	72.2	128.3	212.7	301.0	96.0	114.3	56.1	160.6	152.1	274.9
16	—	—	—	—	—	—	122.8	131.1	75.3	261.2	198.1	392.3	—	—	—	—	—	—
19	79.2	157.1	131.6	134.1	210.8	291.2	116.4	164.8	87.3	224.5	203.7	389.3	71.1	94.9	121.1	227.9	192.9	322.8
	Age of seedlings—appearance of first blossoms.												Age—fruiting.					

evident only with the beginning of photosynthesis. It should be noted that during the remaining light hours the amount of soluble carbohydrates in the leaves of experimental plants was considerably higher. This may be accounted for by their more intense storing in the course of CO_2 assimilation, which is supported by the figures given in Table 3, as well as by Fig. 1. The maximum excess of soluble carbohydrate content in leaves of experimental plants, as compared with controls, was equal in cucumber plants to: 9.VII—98.7%, 10.VII—41.4%, 27.VII—33.8%; in lettuce it equalled: 20.VII—28.6%, 21.VII—36.8%. Thus, the total store of carbohydrates in the experimental plants was higher by 59.8, 98.0, 67.7, 33.8 and 19.3% respectively. By the end of the day (at 19 o'clock) the absolute amount of carbohydrates in the leaves somewhat decreased, while the above ratio between the control and experimental plants remained essentially the same. Confronting the data of analyses with the intensity of CO_2 assimilation, we become aware of their absolute agreement as to the final conclusions that may be derived therefrom: photosynthesis in the experimental plants proved considerably higher, except three cases when dissimilation was observed. Thus, we see no ground whatever to question the data on the positive influence of increased CO_2 concetrations upon photosynthesis, as obtained by number of authors by the method of constant air flow. Our special investigation ([13]) has shown that the plant's respiration is considerably enhanced in an atmosphere enriched with CO_2 (about

Table 2

Dynamics of Carbohydrate Accumulation in Leaves of Lettuce as Influenced by Various CO_2 Content in Air (in mg of glucose reduced to 1 g of absolutely dry leaves)

Hour	20.VII						21.VII					
	Soluble		Insoluble		Total		Soluble		Insoluble		Total	
	Control	CO_2	Control	CO_2	Control	CO_2	Control	CO_2	Control	CO_2	Control	CO_2
4	56.5	49.5	48.5	55.9	105.0	105.4	68.3	68.7	54.8	62.9	123.1	131.6
8	84.2	80.6	28.0	31.0	112.2	111.6	—	—	—	—	—	—
11	82.7	86.9	25.3	26.9	108.0	113.8	—	—	—	—	—	—
13	70.7	79.6	55.6	59.2	126.3	138.8	77.0	92.5	50.1	42.7	127.1	135.2
16	95.2	128.8	31.8	41.0	127.0	169.8	—	—	—	—	—	—
19	76.8	98.8	64.2	65.7	141.0	164.5	94.9	130.8	55.1	48.8	150.0	179.6

Age—appearance of first flower sprouts

1½—3 times). This makes us suggest that the increase of CO_2 content in the air is accompanied not only by a more intense storing of carbohydrates, but also by an enhanced breaking up of the latter in the process of respiration, some inner energy necessary for the organism being liberated.

Thus, when using CO_2 as fertilizer we cannot consider it as a mere stimulating agent. At high concentrations and when used for a long period, CO_2

Table 3

Photosynthesis in Plants as Influenced by Various Content of CO_2 in Air, Estimated by the Method of Constant Air Flow

Plant	Date	No of test	Time of determination		Assimilation of CO_2 in mg per 1 dm^2 per hour			
			hrs	min.	at 0.06% CO_2		at 0.90% CO_2	
					absorb.	given off	absorb.	given off
Cucumber plants	9.VII	1	6	15	11.2	—	32.7	—
		2	9	25	13.4	—	71.4	—
		3	11	25	19.1	—	49.2	—
		4	14	48	12.5	—	37.4	—
		5	20	15	7.6	—	14.0	—
»	10.VII	1	5	10	0.0	0.0	95.4	—
		2	7	52	5.4	—	14.8	—
		3	11	30	12.7	—	65.4	—
		4	14	40	—	5.5	50.3	—
		5	17	52	—	43.8	37.0	—
Lettuce	20.VII	1	6	26	17.5	—	—	5.6
		2	9	50	4.5	—	38.1	—
		3	12	05	6.3	—	—	4.4
		4	14	55	3.4	—	7.0	—
		5	17	59	5.1	—	15.3	—
»	21.VII	1	6	45	2.6	—	14.6	—
		2	9	57	14.1	—	—	11.0
		3	12	11	4.5	—	16.8	—
		4	15	29	6.0	—	5.5	—
		5	18	01	11.2	—	15.2	—

produces deep changes in the physiological processes proceeding in the plant's organism. In particular CO_2 enhances the energy of photosynthesis, favourably influencing the dynamics of storing of carbohydrates and intensifying the process of their disintegration in the course of respiration. As the increase of carbohydrate synthesis induced by CO_2 predominates over their loss through intensified respiration, this results in a higher content of carbohydrates in the leaves of experimental plants, as revealed by the analyses.

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PLANT PHYSIOLOGY

EFFECT OF CO_2 UPON TRANSPIRATION AND STOMATIC APPARATUS IN PLANTS

By L. M. DOROKHOV

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The question as to the influence produced upon plants by increased CO_2 content in air was more and more engaging the interest of investigators and practical growers within recent years. The interest rose in connection with the large scale building of green- and hothouses, provided with technical heating and short therefore of carbon dioxide. To clear up the phytophysiological nature of CO_2 action upon plants has thus become a problem of great practical importance. In our previous works we have described the changes due to the action of CO_2 we had observed in vegetables with regard to yield and photosynthesis (1), respiraton (2), and dynamics of carbohydrate sto-

Table 1

Daily Transpiration of Plants as Determined by Different Content of CO_2 in Air

Plant	Date	Water (in g) evaporated by one plant within 24 hours		Transpiration (in g) per 1 dm² of leaf area within 24 hours	
		Control	CO_2	Control	CO_2
Cucumber	15.VII	286.0	322.0	15.1	13.2
»	16.VII	373.0	336.0	19.5	13.8
»	10.VIII	855.7	734.7	16.4	13.0
»	11.VIII	1052.0	917.7	20.1	16.3
»	28.VIII	423.7	367.7	20.2	20.3
Average		598.8	535.6	18.3	15.3
In %		100	89.4	100	83.6
Tomato	16.VII	264.0	190.0	28.4	19.8
»	2.VIII	505.5	423.0	8.8	6.9
»	3.VIII	668.5	642.0	11.7	10.5
Average		479.3	418.3	16.3	12.4
In %		100	87.2	100	76.0

ring. The present work is devoted to the question of how the transpiration and the movements of stomata are affected by increased content of CO_2 in air.

The transpiration was studied on cucumber and tomato. The plants were grown in Wagner's vessels which had been placed into hot chambers of 18 m^3 volume each. In two of the latter (test chambers) the average content of carbon dioxide in air was brought up to 0.40% for tomato and 0.76% for cucumber plants. In control chambers the average concentration of CO_2 did not exceed 0.06%. Humidity and temperature of the air were kept up on the same level in all chambers. The plants were growing under different conditions with regard to carbon dioxide throughout the summer. Transpiration was periodically estimated by weight.

In Table 1 we see a lower intensity of transpiration both in cucumber and tomato plants against a higher concentration of CO_2. The average amount of water lost by a plant within 24 hours in test chambers was by 10.6—18.8% less compared to controls; daily transpiration per 1 dm^2 of leaf area

Table 2

Effect of CO_2 upon Width of Stomata in the Upper Leaf Surface of Tomato

Date	Time		Average width of aperture		Light conditions
	hours	min.	with 0.06% CO_2	with 0.40% CO_2	
2.VIII	6	25	4.6	2.0	Mist
	6	51	2.2	1.5	»
	8	10	3.9	2.5	Clear day
	10	07	5.3	2.1	» »
	12	31	2.4	0.3	» »
	14	13	3.0	0.7	Cloudy day
	16	12	4.0	2.0	» »
	16	38	3.1	0.8	» »
	18	09	2.3	0.8	» »
	20	09	1.8	0.5	» »
Total			32.6	13.2	
Average			3.26	1.32	
In %			100	40.5	
3.VIII	6	08	3.5	0.6	Mist
	6	19	2.7	0.4	»
	8	07	5.1	2.3	Clear day
	8	22	4.0	1.6	» »
	10	08	6.0	3.4	» »
	14	13	3.2	1.6	» »
	16	06	1.0	0.4	» »
	18	04	2.4	0.6	» »
	18	19	1.9	0.5	Cloudy day
	20	09	2.6	0.5	» »
Total			32.4	11.9	
Average			3.24	1.19	
In %			100	36.8	
Average width from two days observations			3.25	1.26	
In %			100	38.8	

was respectively lower by 16.4% in cucumber and by 24.0% in tomato. These data on vegetables perfectly agree with the observations reported earlier by N. N. Kisselew (3) who experimented with *Matthiola annua* and *Fuchsia hybrida*. We may, thus, infer that there are many plants which respond to increased concentration of CO_2 in the air by lowering their transpiration.

Water vapour diffuses from the intracellular spaces in the outside through stomata, which pervade the leaf cuticle. Naturally enough we had to pay attention to the behaviour of stomata with different concentrations of CO_2 in the air. The question of how wide open become stomata was studied in tomato plants on Aug. 2 and 3 by Lloyd's fixation method (4). Width of the aperture was measured under microscope with the aid of an ocular micrometer. Average width in μ was derived from 52 measurings for each interval of observations. Within 2 days we have examined the plants both in control and test chamber and measured 1040 stomata in each. In Table 2 we see narrower openings under higher concentration of CO_2.

If the average daily width of stomatic aperture in controls be taken for 100, the respective figures for experiments will be: Aug. 2—40.5%, Aug. 3—36.8%; and the average for both days, 38.8%. In other words, the test plants had 2.5 times less wide opened stomata and in certain hours they were still more closed than this. With regard to the length of stomata, no difference has been revealed. The average value was 6.86 μ or 6.91 μ at 0.06% and 0.40% concentration of CO_2 respectively. Number of stomata per 1 mm² of upper leaf surface was 93 in controls and 85 in experiments.

From the average number of stomata, the average width of aperture (control, 3.25 μ, experiment, 1.26 μ) and length of stomata we have determined the aggregate area of opened stomata per 1 dm² of upper leaf surface. It was found to be equal to 15.54 and 5.99 mm² according to concentration of CO_2, i. e. 0.06 or 0.40% respectively. In estimating the area of opened stomata their shape was considered as ellipse.

Table 3

Transpiration of Tomato per 1 mm² Area of Opened Stomata

	Plants		Ratio	
	Control	Experiment	Control/CO_2	CO_2/Control
Aggregate area of opened stomata (in mm²) per 1 dm² of leaf surface	15.54	5.99	2.59	—
Average transpiration (in mg) in tomato on Aug. 2 and 3 per 1 dm² per hour	678.8	527.7	1.3	—
Transpiration (in mg) per 1 mm² of opened area of stomata . .	43.6	88.1	—	2.02

The data referred to show the aggregate area of opened stomata to have decreased 2.6 times under the influence of CO_2. In spite of the transpiration in tomato being reduced 1.3 times within two days by increased CO_2 concentration, its intensity reduced to 1 mm² opened area of stomata was two times higher in experiments than in controls. This evidences that the diffusion of water vapour in the outside is stronger in leaves with smaller diameter of stomata. No strict proportion could be established between the width of opened stomata and transpiration. When the average width of stomata decreased 2.5 times compared to controls, the decrease of the trans-

piration was only 1.3 times. Our data support the conclusions of Stälfelt[5] who has discovered that the most marked response of photosynthesis and transpiration to the opening of stomata apertures is observed in the case when the initial width of the apertures is very small.

The experiments described lead to the following conclusions: 1) increased concentration of CO_2 in the air causes the plants to contract the width of opened stomata markedly (up to 60%) compared to controls; 2) this leads to notable drop (up to 24% in tomato) of the transpiration from unit leaf area and lessens the amount of water lost by evaporation; 3) the rate of water vapour diffusion from the intracellular spaces of the leaf in the outside per unit area of opened stomata is greatly enhanced under the influence of CO_2.

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PLANT ANATOMY

ON STRUCTURE OF FURROW IN WHEAT KERNEL

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It would seem that the structure and morphology of cereal kernel have been exhaustively studied, but it is surely not so. No definite answer, for instance, has as yet been given to the question whether the pistil of cereals has one or three capillaries when it is appearing and forming (1). Concerning this question, we are lacking any differentiation even with regard to the kernels of most widely cultivated cereals. Our knowledge of the structure of furrow is also far from being complete, though a number of facts seem to bear evidence for its playing the rôle of a tract through which substances pass to fill the cells of the endosperm. If so, it deserves our special attention as a part involved in the process of grain's filling. In the present communication we are reporting some of our results obtained from investigating the structure of the furrow of wheat.

If transverse sections have been made through a wheat kernel (better if through a waxy ripe one, i. e. such as had not yet got completely mature and dry) on different levels from the basal end to the top, we can observe conducting elements in the region of the furrow which are standing out of the parenchyma by their thickness, special lustre of integuments and different contents. In the basal and mid region of the kernel (Fig. 1, left) the conducting system consists of xylem and phloem, the latter having more dense contents and being separated from the former by intercalations of parenchyma. In the upper regions of the kernel (Fig. 1, right) xylem elements disappear and the phloem is often reduced to only one string. In a quite mature wheat kernel the conducting anatomical elements are found only in the furrow. It is not to be denied that in relation to the size of the kernel the system of conducting elements is but poorely developed, and besides no elements of phloem and xylem are present in the top of the kernel.

Since the transverse sections through the kernel in the region of the furrow afford no possibility to form a clear idea of how the conducting system is spread and to what extent it is developed, it will be better to examine the kernel from the plane on material cleared with chloral hydrate (all figures, except Fig. 1).

Fig. 2 represents a fragment from the basal region of the furrow in a young kernel of *Tr. sphaerococcum* grown half its ultimate size. At the base of the kernel the net of conducting elements in the furrow is fairly dense; for the most part, it consists of comparatively short, well separated tracheid-like cells (hydrocytes). Four branches of those elements may definitely

be traced: two of them lead towards the apical region of the kernel, two are running along the flanks to the place where the developing embryo is situated. As the kernel develops, the anatomical elements in the conducting system of the furrow increase their length markedly, especially in the mid part of the kernel. Xylem elements thereby assume the shape of typical vessels with spiral or reticulate (primitive) swellings. Fig. 3 represents a portion of furrow tissue from the upper half of a young kernel, variety *Lutescens* 062 (*Tr. vulgare* v. *Lutescens* Al.). The conducting elements in the upper part of the kernel are by far not so dense as at the base. As the elements of xylem (with lignified integuments) approach to the top, their size diminishes while the elements of phloem become more and more conspicuous. In Fig. 3 the elements of phloem are situated on both sides of the string, which is made of vessels; the swellings of their walls show nearly the same pattern as in the elements of xylem, but for the absence of lignified integuments. This analogy between xylem and phloem elements as regards the pattern of their swellings has already been pointed out by Alexandrov and Abesadze (2).

Fig. 1—6.

The parenchyma, which envelops the conducting elements in the upper half of the kernel, is provided with a well developed system of intercellular spaces (Fig. 3). In the top region of a young kernel this system is still more abundant (Fig. 4, *Lutescens* 062), the strings of conducting elements gradually disappear, beginning with elements of xylem, the parenchyma is more rounded out and provided with conspicuous slit-like pores. The pores, fairly rich in number at first, disappear gradually in the direction towards the top, as the cells become more rounded out and smaller in size. In the top there are no pores at all and a very loose tissue is formed which consists of round cells with thin walls and is pervaded by a dense net of intercellular ways. This tissue is covered by pilose epidermis with lots of stomata dispersed among hairs. The presence of numerous stomata on the walls of wheat ovary has already been noted by Nowacki(3). Fig. 5 represents a portion of epidermis from the top of a waxy ripe kernel *Tr. polonicum*. It is noticeable that the stomata are not of a cereal type, but such as usually occur in other plants. By investigating the structure of the epidermis in the top of a young kernel in greater detail, we find the epidermic cells to have the same slit-like pores as are peculiar to the parenchyma of top tissue and to

remind in that point of the transverse cells of the kernel, i. e. cells of the inner epidermis (Fig. 6, *Lutescens* 062). Each hair in its basal end immersed amidst epidermic cells has well developed tubes (Fig. 6, right), ending into pores which communicate with the pores of epidermic cells lying around (Fig. 6, left). Young kernel has soft hair with tender but fairly thick membranes. The hairs are filled with live matter, show a large vacuole, and seem to be deprived of cuticle, unless the latter is very thin and therefore hardly distinguishable.

Before we attempt to interpret the structure of the inner tissue of furrow as well as of that of the top of wheat kernel, we will point out that this structure changes as the kernel ripens. Its maximum development the system of conducting elements in the furrow attains in a young, growing and filling kernel. When the grain is near to get completely mature (at the stage of waxy ripeness), a great part of anatomical elements in the xylem and phloem have already been obliterated and have disappeared, being involved in the general obliteration of the mesocarp tissue in the ripening kernel. In a mature kernel of some wheats we not seldom see the conducting system of the furrow to have been so much reduced that it is hardly distinguishable. The structure of the hairs on the top of wheat kernel has also changed: the hairs have lost their life contents and appear hard and coarse; their pore tubes have grown close in the basal end and may hardly be discerned. The tender cellular substance of their membranes has begun to lignify. Lignification is strongly expressed in the top hairs of a mature wheat kernel, which form a so-called «brush». In hard wheat, for instance, the hairs of the brush have often been noted to present the only lignified elements among the tissues of the pericarp.

By comparing different varieties of wheat, we have established that the conducting system of the furrow and the brush functionally connected with it are most strongly developed in those wheats which excell in rapid or strong filling. Thus, the conducting system of the furrow is very rich in *Tr. sphaerococcum*; as a rule, it is better developed in soft wheat than in hard wheat. Aside from the conducting system of the furrow which in its rudimental state consists, according to Schuster ([4]), of three bundles (two lateral bundles with one placental bundle between them), there appears one more, poorly developed bundle in the wall of the ovary on the dorsal side. This latter bundle, however, becomes obliterated soon after it has formed. As a matter of fact only the ventral group of bundles is functioning during development and filling of wheat kernel, i. e. the bundles lying in the region of the furrow. The conducting system of the furrow is the only conducting system of the cereal ovary and the fruit forming from it. No doubt therefore that the function of the system as well as of the whole mechanism described above is intimately linked with the filling of grain.

According to a number of works ([5], [6], [7]), cutinization and suberization of the integument and placenta-chalezal region begins very early in a developing kernel, when the latter has grown but little, and is almost quite completed at the outset of waxy ripening. Only the region of micropile and top are not involved in the cutine-suberine metamorphosis. The early cutinization of the integument, which completely envelops the endosperm and turns into seed-coat at the beginning of waxy ripening, is undoubtedly a great obstacle for the substances filling the endosperm to be admitted in the cells of the latter. And we know that at the outset of that stage the fine (chondriosome) starch is still continuing to fill the cells of the endosperm. It seems that a fair portion of substances stored in the endosperm of a kernel have passed through the apical region. The peculiarities of the structure we have observed in the top of the kernel, i. e. the net of parenchyma with

slit-like pores and the soft hair with stomata, probably constitute a mechanism which promotes filling. The solutions are drawn towards the top by the transpiring activity of the hairs and stomata. There are, of course, other ways except that through the top, but the apical mechanism accelerates the process of filling considerably. We thus conclude that the brush of a ripe kernel is a remnant of the part of a mechanism involved in the filling of grain.

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PHYTOPATHOLOGY

ALTERATION OF PHYSIOLOGICAL PROCESSES IN TOMATO UNDER THE INFLUENCE OF *CLADOSPORIUM FULVUM* Cke

By L. M. DOROKHOV

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When the fungus *Cladosporium fulvum* Cke comes to live on the leaves of tomato, it attacks the assimilating organs of the plant whose yield of fruit drops then markedly and often the plant itself is killed. This disease seriously interfers with a profitable cultivation of tomato under hothouse conditions. On that account the Laboratory of Plant Physiology, Scientific Research Institute of Vegetable Crops, entered in 1936 upon an investigation of the nature of this disease.

Variety «Sparks Gribovsky» was taken as host plant for the experiment. In the first series of tests we were concerned with the question of how the products of fungus' life activity affect the seeds and vegetating plants. To obtain those products *Cladosporium fulvum* was grown in a thermostat at 22—25°C. The nutritive medium of Richard (1) was used, with the following compositions: water, 1000 cm³; KNO_3, 10 g; KH_2PO_4, 5 g; $MgSO_4$, 2.5 g; $FeCe_3$, 20 mg and glucose, 50 g.

The solution was poured into flasks of 250 cm³ capacity and after sterilization inoculated with the pure culture of the fungus. The mycelium, formed 30 days later, was filtered off, the filtrate was subjected to fractional sterilization and thus used in experiment. Undissolved filtrate we denote in the following with 100%.

The seeds of tomato were brought to germination in Petri dishes, on filtering paper wetted with the substratum under test or with water. From Table 1 it may be seen that in the pure 25% solution of Richard the seeds were germinating normally, while only 18—40% of them have germinated in the filtrate of the same concentration from the culture of *Cladosporium fulvum*.

With the concentration of the latter exceeding 25% there was no germination at all. Yet the energy of germination was by far not so low if instead of Richard's solution an extract from the leaves of tomato had been inoculated with the fungous culture. The reason of this may lie in the fact that in the leaf extract we observed a 20—25 times weaker growth of the fungus. Seeds which had to germinate in a water extract of mycelium were materially checked only if the concentration was 100%.

Seeds which within a fortnight failed to germinate in a 50—100% filtrate from *Cladosporium fulvum* were carefully washed with water and transferred into Petri dishes, where their germination in water begun as early as after 24 hours.

Table 1

Experiment from February 17 till February 28

Substratum	Concentration in %	% of seed germinated				
		20	22	24	26	28
1. Water	—	23	75	82	83	83
2. Filtrate from the fungous culture grown in the leaf extract	1	21	71	76	81	81
	50	2	19	46	56	63
	100	0	2	11	19	20
3. Filtrate from the fungous culture grown in Richard's medium	1	17	76	81	82	82
	25	2	2	13	35	40
	50	0	0	0	0	0
	100	0	0	0	0	0
4. Richard's medium	1	26	71	78	81	81
	25	10	24	62	79	82
	50	Mold fungi appeared				
	100	»	»	»		

This series of tests has shown that *Cladosporium fulvum* while growing in a nutritive medium enriches the latter with the products of its life activity—toxines, which supress the life activity of seed embryos.

In further experiments the majority of the tomato seedlings grown on a 1, 5, 10 or 25% filtrate from the fungous culture perished after they had been transferred in Knopp's nutritive solution. The plants survived grew weakly, with only 1—2 underdeveloped yellow-coloured leaves, poor in chlorophyl. Similar picture was observed with the plants grown from the seeds which had been kept for 10—15 days in a 50—75% filtrate and afterwards germinated in distilled water. The toxical effect of fungous life activity products was noted moreover when growing tomato on Knopp's nutritive solution added by a 5, 10 or 25% filtrate. The 25% concentration of the filtrate poisoned the plants which perished in 30—35 days. Total death of the plants was preceded by weak growth, pronounced ethiolation of leaves and a gradual dying away of the point of growth of the stem.

With a 10% filtrate part of the plants lived out, yet there was observed yellowing and drying of the upper young leaves. When a 5% filtrate had been added to Knopp's medium, the plants did not perish, but in that case too the leaves looked yellow, the chlorophyl being destroyed in them. In one of the variants of this experiment the plants within two months attained a height of 4—6 cm only and had markedly short internodes. These plants were rapidly shedding their leaves which were then replaced by new ones. The pale green of the leaf blade turned later into dense violet. Curiously enough, in the papers by Sukhorukov ([2]) and Ovčarov ([3]) we already find indications as to the breaking up of the chlorophyl under the action of one of the components entering into the composition of the rust toxines, viz. thiourea.

The observations referred to above enable us to conclude that the products of fungus' metabolism are excreted into the nutritive medium it is growing in. Once introduced into plants' tissues either artificially or while *Cladosporium fulvum* is developing on the leaves, these products act as toxines and provoke partial or total poisoning of host's cells. Our observations on the dying away of tissues in tomato under the action of toxines agree with the results obtained by A. A. Richter ([4]) who has investigated the discharging of rust toxines and their effect upon the isolated tissues of higher plants.

We experimented on tomato plants grown in a special hotchamber and infected naturally. The energy of photosynthesis and the respiration of lea-

ves affected in different degrees by *Cladosporium fulvum* have been estimated.

In estimating the photosynthesis and respiration the method of constant air flow was made use of. The carbon dioxide was captured by Richter's absorbers ([5]). As seen from Table 2, the infection of tomato leaves by *Cladosporium fulvum* lowers both photosynthesis and respiration. The higher the ratio of the leaf area infected with fungus colonies, the more the intensity of both processes is depressed. Especially strong is the influence upon respiration. It should be noted here that our data on respiration do not agree with the observations made by Grechushnikov ([6]) who in his work on oats attacked by *Puccinia coronifera* came to a quite different conclusion. The disagreement may possibly be accounted for by the different biological nature of the plants tested.

Transpiration was studied in leaves cut off in water and standing on their petioles in flasks filled with distilled water.

Table 2

	Beginning of test		Exposition in min.	Ratio of infected leaf area, in %		Photosynthesis and respiration in mg CO_2 per 1 dm^2 per hour			
	hrs	min.		leaf 1	leaf 2	Photosynthesis		Respiration	
						leaf 1	leaf 2	leaf 1	leaf 2
Photosynthesis	10	17	47	0.8	40.0	14.1	10.7	—	—
»	13	53	52	5.6	94.3	18.4	13.6	—	—
»	10	14	40	3.9	96.3	18.9	13.0	—	—
»	14	42	54	3.9	96.3	11.8	8.3	—	—
Respiration	11	00	56	0.0	21.0	—	—	15.1	2.0
»	13	00	45	0.8	40.0	—	—	12.0	2.5
»	15	25	44	0.8	40.0	—	—	15.0	3.7

Weighing was made every 24 hours in analytical balance. After the second weighing (August 20) five leaves of tomato were inoculated with the spores of the fungus and put with five control leaves into a moist chamber which had two separate sections. In spite of the sections being insulated by three layers of wet gauze, we observed under the magnifier fungous colonies to appear on all leaves three days later. This induced us, in treating the data of the experiment, to divide all leaves into two groups. To the first group we referred the leaves which in the end of the experiment had 6% of their area occupied by the colonies of the fungus; more badly infected leaves were classed in the second group. From Table 3 it may be seen that the transpiration is going up abruptly as *Cladosporium fulvum* develops on the leaves.

Table 3

Group of leaves	Average transpiration from 1 dm^2 of leaf area within 24 hours						
	Previous to infection		After infection				
	in g	in %	% of leaf area under fungous colonies	August 23—25		August 25—27	
				in g	in %	in g	in %
I	5.176	100	1.6— 4.8	6.532	100	5.100	100
II	4.728	91.3	6.1—46.3	9.286	142.0	7.142	140.6

Following conclusions may be drawn from the data of our experiment:

1. While *Cladosporium fulvum* develops in a nutritive medium or under natural conditions—on the leaves of tomato, it is discharging, in the surroundings, the products of its life activity—toxines, which essentially change the course of physiological processes in the host plant. The toxines excreted by the fungus check the development of the seed embryo. Introduced in plant's organism artificially they cause partial or total poisoning of the cells and break up the chorophyl. The plants of tomato perish if the concentration of the toxines of *Cladosporium fulvum* is high.

2. Intensity of photosynthesis and respiration are notably reduced in the plants infected with the fungus. This may be put down to the destruction of the chloroplasts and poisoning of the plasma of plants' cells by the products of the life activity of the pathogenic organism.

3. The transpiration of tomato is considerably increased under the action of *Cladosporium fulvum*. This may be connected with the destruction of the tissues by fungus' hyphae penetrating the parenchyma of the leaf.

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ZOOTECHNIQUE

BLOOD VALUE OF YAROSLAVL CATTLE IN CORRELATION WITH BODY WEIGHT AND YIELD OF MILK

By V. I. PATRUSHEV

(Communicated by N. I. Vavilov, Member of the Academy, 27.VII.1938)

It was shown by Durst and many other authors that milk cows are marked by their respiratory type of constitution and are distinguished from the

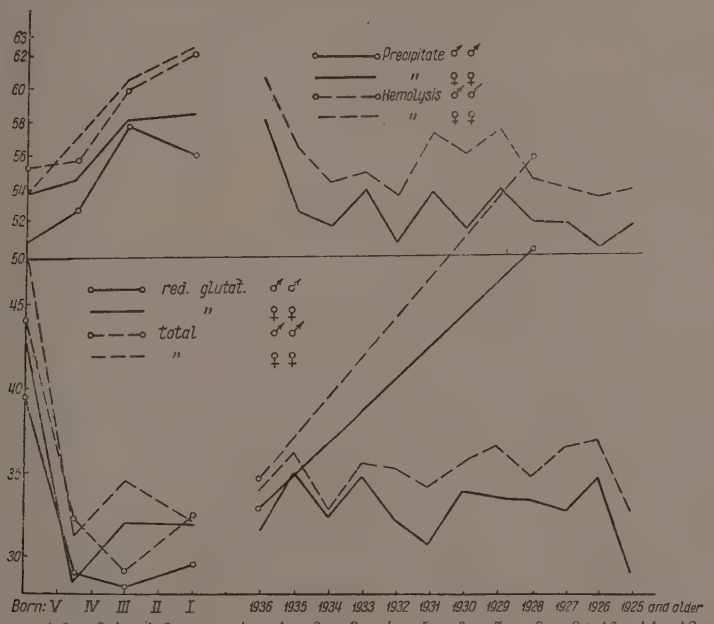

Fig. 1. Age variation of osmotic resistance of erythrocytes (upwards) and concentration of glutathione of blood (downwards) in Yaroslavl cattle.

meat stocks (digestive type of constitution) by their general build, relative volume of lungs, blood value (greater oxidizing surface of blood) etc. (6).

It was our object to ascertain the differences in blood composition of specimens within a breed in correlation with the differences in body weight and yield of milk.

Our investigation was made in June 1937 at the Uspenskaya state farm on Yaroslavl breed of cattle. Two hundred and seventy head of cattle of

various ages and of both sexes were examined and analyses were taken for all blood factors. The animals were grazing and received fodder in addition. The night before examination the animals were given neither food nor water. Blood was taken in the morning from the jugular vein after the cows were milked and before they were given water and taken to graze.

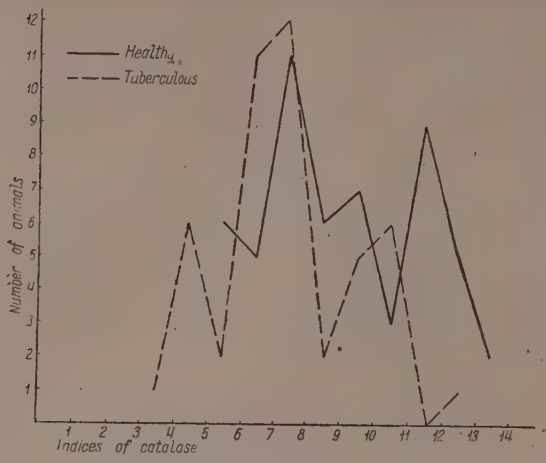

Fig. 2. Distribution of Yaroslavl cows as to catalase activity of blood.

Sex and Age Differences. The glutathione concentration and resistance of erythrocytes, more than any of the other blood factors examined by us, are subject to change under the effect of age (Fig. 1). The effect of age on catalase content, specific gravity and dry residue is less marked. The content of total and reduced glutathione shows a sharp decline in the first six weeks after birth ($\frac{43}{56}$ $\frac{28}{31}$ mg %; the numerator indicates the reduced glutathione and the denominator the total glutathione). After six weeks the glutathione concentration gradually increases until the animal reaches the age of two years; thereupon the blood factors remain relatively stable until the age of ten years, following which they show a sharp decline.

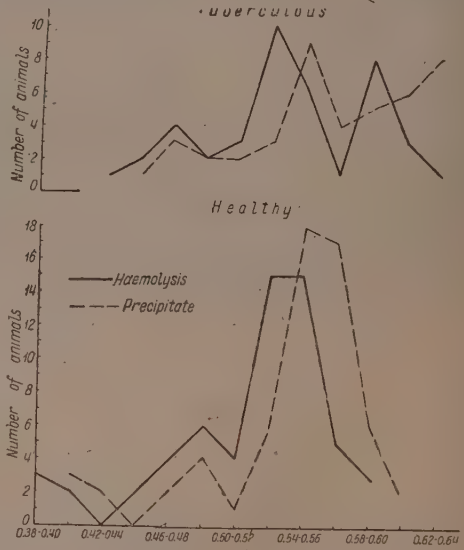

Fig. 3. Distribution of Yaroslavl cows as to the osmotic resistance of erythrocytes.

Beginning with the age of two years sex differences as reflected in glutathione concentration are clearly in evidence. While the blood value of heifers remains relatively stable, the content of glutathione in the blood of young bulls continues to increase.

The resistance of erythrocytes to low concentrates of solutions of salt continues to diminish from birth until the age of six months, after which it rises until the animal reaches the age of three years when a gradual increase is to be observed in the resistance of the erythrocytes. Between the ages of six and eight years (four—six calvings), i. e. the period of highest milk productivity, this gradual increase gives way to a significant drop in the resistance. Equally significant is the fact that from the age of eight years (six calvings) cows begin to show a decline in body weight. Represen-

ted graphically the glutathione concentration, the dry residue and the specific gravity of the blood of adult animals show a unicolumnar curve of distribution. By their catalase activity and resistance of erythrocytes all animals may be divided into three distinct groups differing from each other in the value of the factors (Fig. 2 and 3). This applies to both healthy and tubercular animals. Cows with a positive tubercular reaction which have reached the maximum growth show a higher content of total and reduced glutathione than healthy cows. The resistance of the erythrocytes, the catalase activity and the dry residue of the blood of tubercular cows proved to be lower than those of healthy ones.

Blood Value in Correlation with Productivity. It is noteworthy that according to catalase activity farm animals may be arrayed in three or four groups. On our part we have ascertained the fact that cattle may be similarly classed according to resistance of the erythrocytes. The question naturally arises what is the relation between this array and productivity. Table 1 gives the average figures of body weight for arrays of cows with the highest and lowest catalase activity. In every instance the mean weight of the cows in the highest array for catalase activity was greater than the weight of those in the lowest array. However, not in every instance did the cows in the mean catalase activity array show a mean weight; in regard to weight they sometimes came nearer to the cows of the highest or lowest arrays.

Table 1

Correlation between Body Weight and Catalase Activity

Body weight \ Arrays according to catalase activity	Healthy				Tubercular			
	6.5—8.5		10.5 and over		4.5—5.5		8.5 and over	
	n	*m*	*n*	*m*	*n*	*m*	*n*	*m*
At birth	17	25.6	11	26.6	4	27.7	10	28.0
1st calving	9	373.9	12	394.2	7	374.4	10	382.9
2nd »	10	430.0	9	429.2	5	404.2	7	419.3
3rd »	6	416.1	5	450.0	5	442.0	7	470.7
4th »	5	463.6	3	507.3	3	443.3	6	479.9
5th »	4	466.2	3	602.0	7	469.6	5	493.2

n in this and in the other tables signifies number; *m* signifies mean.

Table 2

Correlation between Body Weight and Resistance of Erythrocytes

Age groups \ Arrays according to resistance of erythrocytes	Body weight							
	Haemolysis				Precipitate			
	42—52		58 and over		44—54		58 and over	
	n	*m*	*n*	*m*	*n*	*m*	*n*	*m*
At birth	11	27.7	6	27.9	10	27.8	12	27.9
1st calving	11	382.7	10	375.2	10	385	8	356.0
2nd »	9	424.0	7	403.7	8	428	13	405.9
3rd »	8	451.0	9	444.5	7	461	15	456.6
4th »	6	484.8	5	455.8	6	485	8	475.0
5th »	6	482.0	8	478.0	6	482	3	472.0
6th »	5	503.5	5	495.0	4	505	5	501.0

Table 2 compares the body weight of cows in both the highest and lowest arrays for resistance of erythrocytes. In all cases, with the exception of newly born calves, greater resistance of the erythrocytes corresponded to a greater body weight.

Table 3 shows the correlation between body weight and the other blood factors. From the data it is evident that animals with a high concentration of total and reduced glutathione and a higher specific gravity and dry residue (plus variants) have on the average a greater body weight than the minus variants.

Table 3

Correlation between Body Weight and Blood Value

Groups of animals	Glutathione								Specific gravity				Dry residue			
	Reduced				Total											
	—		+		—		+		—		+		—		+	
	n	*m*	*n*	*m*	*n*	*m*	*n*	*m*	*n*	*m*	*n*	*m*	*n*	*m*	*n*	*m*
Female calves, 1936:																
9 months old . .	5	192	10	197	9	151	7	193	—	—	—	—	—	—	—	—
3 » » . .	9	83.5	13	87.4	12	83.2	11	85.7	—	—	—	—	—	—	—	—
Young bulls, 1936:																
9 months old . .	7	202	8	213	—	—	—	—	8	202.6	3	204.3	—	—	—	—
3 » » . .	12	82	8	93	11	83	8	101	11	80	5	94	—	—	—	—
Cows, healthy ones:																
Body weight on May 20, 1937 .	35	425	28	428	21	422	40	428.6	14	419	22	437	21	428	25	439

However, these correlations only indicate the average and in a number of cases the blood value differences are not particularly great. It is impossible to draw conclusions on the qualities of an animal solely on the basis of blood value. As an illustration we shall give the comparative data of the blood value of two young bulls of the same age but of different body weight.

1. No of animals . . .	235	239
2. Body weight: . . .		
a) at birth	35	22
b) one month old . .	53	26
c) two » » . .	75	42
d) three » » . .	83	61
3. Glutathione . .		
a) reduced	28.8	26.9
b) total	31.9	29.1
4. Dry residue . .	20.0	19.2
5. Specific gravity	1.0477	1.0440
6. Catalase	7.5	9.8
7. Resistance: . . .		
a) haemolysis . .	0.60	0.52
b) precipitate . .	0.64	0.54

When the differences in body weight are smaller, there is very often either no difference at all in the blood value or if there is a difference it is still more insignificant. Thus, when evaluating pedigree animals the blood value may be taken into account only as data supplementary to those, obtained by ordinary zootechnical methods. By examining and reexamining large numbers of animals, under different conditions, for blood value, supplementary data may be obtained for the purposes of selection.

Comparing the average yield of milk for the lactation period of 300 days by cows grouped in arrays by catalase activity and resistance of blood, we find the same regularity as was observed in regard to body weight. Cows

Table 4

Correlation between Yield of Milk and Catalase Activity

Catalase array / No of lactation	Yield during lactation period of 300 days (in litres)					
	6.5—8.5		8.5—10.5		10.5 and over	
	n	*m*	*n*	*m*	*n*	*m*
1	10	2202.41	5	2436.8	7	2463.5
2	8	2628.4	5	2640.6	8	2704.9
3	4	1941.5	3	2423.6	2	2810.5
4	3	2633.0	3	2543.6	2	2637.0
5	3	2901.5	3	3089.0	1	2712.0
6	2	2452.4	3	3028.1	3	3665.5
7	2	3046.25	—	—	3	3294.3

Table 5

Correlation between Yield of Milk and Resistance of Erythrocytes

Catalase array / No of lactation	Yield per 300 days of lactation (in litres)							
	Haemolysis				Precipitate			
	42—52		58 and over		44—54		58 and over	
	n	*m*	*n*	*m*	*n*	*m*	*n*	*m*
1	6	1978	9	2000	5	2026	17	2223
2	6	2939	8	2142	5	2858	15	2483
3	—	—	—	—	—	—	—	—
4	5	3081	4	2649	5	3081	7	3046
5	3	2944	1	2334	4	3020	2	2797
6	2	3274	2	2943	3	3213	4	3013
7	—	—	—	—	2	4893	1	3060

showing greater catalase activity and great r resistance of erythrocytes give on the average a greater yield of milk than cows with a lower blood value.

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PALEONTOLOGY

REMAINS OF *UNGULATA* FROM BET-PAK-DALA

By K. K. FLEROV

(Communicated by A. A. Borissiak, Member of the Academy, 11.VIII.1938)

A small collection of remains of *Ungulata*, gathered by the Second Bet-pakdalian Expedition of the Central Asiatic University, is of particular interest, as some forms have been for the first time found on the territory of Central Asia. The material was collected within the southern boundaries of Bet-pakdala (south-western part of the Famine Steppe) in the vicinity of the salt march As-Kazansor*. The collection contains the following species:

Hemimeryx turgaicus Boriss. There is an incomplete M_3 sin**. The tooth belongs to a more mature animal than the one from Turgai described by A. A. Borissiak, but is quite similar to it in structure.

Brachypotherium sp. The collection contains 4 upper molars, one lower molar and J_2 sin. Comparison of these teeth with tertiary rhinoceroses induces one to believe them to be close to the genus *Brachypotherium*.

Moropus betpakdalensis n. sp. There are a few fragments of jaws with molar teeth, one broken axis, two calcaneum (dex. et sin.) and metacarpale III dex. The bones and teeth belong to animals of various sizes. When comparing these materials from Bet-pak-dala with other *Chalicotheriidae*, we have no difficulty in establishing their great similarity to genera *Moropus*, *Phylotillon* and *Ancylotherium*. The upper molars of the Betpak-dalian species have an elongated form (length considerably exceeding width: length of M_3—55 mm, width—45 mm), the vertical ridge of the ectoloph is very large, sharp, pointed, the median valley nearly vertical. Some distinctions from *Moropus* and *Ancylotherium* may be summarized as follows: the anterior external lobe is greatly elongated, cingulum very sharply pronounced at the posterior part of this lobe, runs but to the middle of its length and abruptly terminates there, further lies a diastema, where a thickening of the enamel at the base of the crown is hardly discernible; whereupon the cingulum is somewhat more strongly developed along the sides of the anterior border only. On the lingual side the teeth display a straight edge of the crown along the anterior cusp whereas in *Moropus* the edge is convex. Comparison of the remaining teeth and bones raises no doubt as to

* All materials are kept at the Paleontological Institute of the Academy of Sciences of the USSR.

** Subsequent excavations in Bet-pak-dala carried out by the Paleontological Institute of the Academy of Sciences of the USSR have furnished rich material on *Anthracotheriidae*.

their belonging to one of the three above-named genera. Owing to the structure of metacarpale III (it has a flat anterior side and a rounded section), the betpakdalian form should be referred to the genus *Moropus* and not to *Pikermian Ancylotherium**.

So far *Chalicotheriidae* were known within the boundaries of the USSR only in the Turgai Upper Oligocene deposits (*Schizotherium turgaicum* Boriss.). The new finding contributes to a considerable expansion of the area of distribution of the group of *Moropus*. The close relation of the Betpakdalian remains to the genus *Moropus* points to a certain resemblance between the Aquitanian faunas of Central Asia and of America; at the same time it testifies to its considerable isolation from contemporaneous European faunas. The Betpakdalian species, characterized by a number of features distinguishing them from American Lower Miocene species (*M. elatus*, *M. petersoni*), should be regarded together with the Beluchistan *Phylotillon naricus* as an Asiatic branch of the genus *Moropus*, which had been the ancestor of the Miopliocene *Ancylotherium* of the fauna of *Pikermi*.

By its contents the Betpakdalian fauna of *Ungulata* is very similar to the Turgai Lower Miocene fauna, the presence of *Moropus* being the only sharp distinction. The absence of the latter in Turgai may be explained by that the *Chalicotheriidae* reached on the territory of Kazakhstan its northern limit of distribution without attaining Turgai. Moreover, such highly specialized animals as *Chalicotheriidae* had undoubtedly been strictly confined to a definite type of landscape and did not been distributed over the whole territory of Kazakhstan, but spread sporadically.

All *Ungulata* from Betpakdala and Turgai are closely allied to the contemporaneous ungulate animals from Beluchistan, but are not identical with them and constitute a rather well differentiated complex of their own. From the Mongolian fauna the one of Kazakhstan is distinguished by the presence of *Moropus* and by a considerable number of remains of *Anthracotheriidae*, which are comparatively rare in Mongolia. The Kazakhstan Upper Oligocene and Lower Miocene fauna sharply diverge from the West Europian (in Europe are lacking: *Hemimeryx*, *Indricotherium*, *Colodon*, *Moropus* and others), and the genera common to both of them yield in Kazakhstan sharply delimited species (*Schizotherium turgaicum*, *Acerathericum depereti*, *Lophiomeryx turgaicus* n. sp., distinguished from the European forms by its considerabl smaller size and having P_1 and P_2 approximated and not separated).

Some resemblance to North America is produced by the presence in Kazakhstan of *Colodon* and *Moropus*. The contents of the Kazakhstan Lower Miocene fauna of *Ungulata* is very characteristic. The presence of a large number of *Anthracotheriidae*, small *Artiodactyla* (*Lophiomeryx* etc.), rhinoceroses of the type *Brachypotherium* and *Chalicotheriidae* points to a characteristic complex of species, peculiar to subtropical regions with considerable humidity, abundant stagnant water basins, dense thickets and swampy areas alternating with vast massive woodlands.

In the opinion of Korovin**, mixed forests of *Carpinus*, *Fagus*, *Juglans*, *Liquidambar* etc. were characteristic for Kazakhstan in Aquitanian time. These humid shady forests with dense crown were bordering on fresh water lakes with abundant aquatic vegetation (*Salvinia*, canes, sedges***). These data are corroborated by studies of insects. A. V. Martynov from Ashutasse

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* It is doubtful whether *Phylotillon* really exists as a separate generic unit distinct from *Moropus*. If later on the existence of the Beluchistan *Phylotillon* will be confirmed, then, perhaps, the betpakdalian species will be referred to that genus.

** «Vegetation of Central Asia» (1934).

*** The Kazakhstan flora was studied by A. N. Krishtofovich and I. P. Palibin [Bull. Acad. Sci. URSS (1918) and consec.].

has described relatively abundant remains of dragon-flies (according to this author, they belong to Oligocene and Lower Miocene).

Such is one characteristic type of the Kazakhstan landscape in the Upper Oligocene and Lower Miocene. But apart from that, there had existed no doubt vast areas of dry, greatly thinned woods and dry tracts of land of the semi-steppe or savanna type, which could be regarded as symptoms of the beginning of the Kazakhstan desert formation at that time.

Under such conditions persisted another group of *Ungulata—Artiodactyla Prodremotherium* which, like the recent antelopes, were probably grazing in large groups, *Indricotherium*, *Epiaceratherium* and others wandering about etc. Termites were also confined to identical conditions*.

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* Oral communication of A. V. Martynov. The termites were described by the same author from Ashutasse. (Труды Геологического музея Академии Наук СССР, т. V).

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